

INTERNATIONAL STANDARD



5

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Photography — Determination of diffuse transmission density

Photographie — Détermination de la densité optique en lumière diffuse

First edition — 1974-10-15

UDC 771.534.531.5

Ref. No. ISO 5-1974 (E)

Descriptors: photography, black and white photography, photographic film, photographic plates, calibrating, photometry, flux density, radiant flux density, transmission.



Documents

Document Sharing Hub

Price based on 19 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (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 set up 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.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, Technical Committee ISO/TC 42 has reviewed ISO Recommendation R 5 and found it suitable for transformation. International Standard ISO 5 therefore replaces ISO Recommendation R 5-1954.

ISO Recommendation R 5 was approved by the Member Bodies of the following countries :

Australia	France	Sweden
Austria	Italy	Switzerland
Belgium	Mexico	United Kingdom
Chile	Netherlands	U.S.A.
Czechoslovakia	Poland	Yugoslavia
Denmark	Portugal	
Finland	South Africa, Rep. of	

No Member Body expressed disapproval of the Recommendation.

The Member Body of the following country disapproved the transformation of ISO/R 5 into an International Standard :

United Kingdom

CONTENTS

	Page
0 Introduction	1
1 Scope and field of application	3
2 General definition of density	3
3 Totally diffuse density	3
4 ISO Standard diffuse density	3
5 ISO Standard diffuse visual density	3
6 ISO Standard diffuse printing density	4
7 Integrating sphere method	5
8 Opal glass method	8
9 Contact printing method	10
 Annex	
A.1 Geometric types of density	15
A.2 Spectral types of density	15
A.3 Complete density classification	17

Photography — Determination of diffuse transmission density

0 INTRODUCTION

0.1 Discussion of density and explanation of terms

Transmission density is defined in general terms as the common logarithm of the ratio of the radiant flux incident on the sample to the radiant flux transmitted by the sample.

When radiant flux is incident on an exposed and processed photographic film or plate, part of the flux is reflected, part is absorbed, and part is transmitted, the transmitted flux usually being scattered. In practice the receiver may collect all or only a portion of the transmitted flux depending on the nature of the receiver and its position relative to the sample. Similarly, as the sample is removed, the receiver may collect all or only a portion of the incident flux. Moreover, the incident flux may be diffuse, or semi-diffuse, or it may be a parallel beam incident at an angle.

Considering some of these possible variations in the geometrical arrangement of the optical system alone, it is apparent that a multiplicity of numerical values of density can be obtained for a given sample depending on how the measurements are made. In any specified geometric condition the effective value of density will also depend on both the colour quality of the light and the colour sensitivity of the receiver, if the sample is spectrally selective. To avoid confusion it is desirable to standardize certain specific methods of measurement.

The problem of establishing a standard of density can be divided into two parts :

- a) Specification of the geometric characteristics of the optical system used in the measurement.
- b) Specification of the spectral sensitivity of the receiver and the spectral energy distribution of the radiant flux incident on the sample.

Variations in the geometrical arrangement of the optical system give rise to a number of geometric types of density which generally lead to different numerical density values.

Among these are found three distinct and fundamental types :

- a) Diffuse density,
- b) Specular density,
- c) Doubly diffuse density.

0.1.1 Diffuse density is obtained when the radiant flux is incident normally on the sample and all of the transmitted flux is collected and equally evaluated. The phrase "collected and equally evaluated" means that the effect on the receiver of all the rays transmitted by the specimen is the same regardless of the angle of emergence. Experimental studies show that the same results are obtained when the incident radiant flux is perfectly diffuse and the specularly transmitted component is collected and evaluated.

0.1.2 Specular density results when the radiant flux is incident normally on the sample and only the normal component of the transmitted flux is collected and evaluated.

0.1.3 Doubly diffuse density is obtained when the radiant flux incident on the sample is completely diffuse and all of the transmitted flux is collected and equally evaluated.

These three types of density are discussed more fully in the annex.

This International Standard is concerned only with diffuse density. This type of density is closely related to many practical applications of photographic materials (see the annex). The characteristics of photographic films are frequently expressed in terms of diffuse density and the term is often used in photographic literature, but it is seldom defined precisely. This International Standard provides a definition (see clause 3) for this type of density and introduces the term "totally diffuse density" as a means of indicating that all of the light is collected.

In totally diffuse density the incident radiant flux is **normal** to the plane of the sample, and all of the transmitted flux is collected and equally evaluated; or, the incident flux is perfectly diffuse and only the normally transmitted flux is collected and evaluated. Moreover, the term signifies that the effects of reflections between the sample and any part of the apparatus (cover glasses, surfaces of the receiver or illuminator, etc.) are negligible and that stray radiation, room light, etc. are excluded.

When the density of photographic films or plates is measured, the diffusion requirements are better satisfied if the emulsion side of the sample faces the receiver which is to collect the transmitted flux. When the incident radiation is diffuse, the emulsion side of the sample should face the diffuser.

The conditions required for the measurement of totally diffuse density cannot be met perfectly, but can be approached very closely, in instruments and apparatus designed for the purpose.

Since the theoretically ideal conditions for totally diffuse density are never met perfectly in practice, the term "ISO Standard diffuse density" has been chosen to designate densities which have been determined under the practical geometric conditions provided by the apparatus and methods specified in this International Standard. The specified apparatus and methods are especially appropriate, however, since they give values of density so closely approaching totally diffuse density that no errors of practical significance arise when the apparatus is constructed and used as specified in this International Standard.

For a sample which is spectrally nonselective the specification of the geometric conditions is sufficient since this specification will lead to a unique value of density. However, for samples which are spectrally selective, it is necessary to consider, in addition, the spectral conditions.

Variations in the spectral conditions give rise to a number of spectral types of density for any given geometric type. Although other important uses of photographic silver images are found in practice, photographic films and plates are usually either viewed by the human eye or printed on positive photographic materials. Therefore, this International Standard specifies in detail only two spectral types of diffuse density, namely :

Diffuse visual density, Type V1-b

Diffuse printing density, Type P2-b

The significance of these terms will be clarified by reference to the density chart in the annex.

The term "visual" is used to indicate that the receiver of the transmitted flux is either the human eye or has a spectral sensitivity equal to it. In the first classification the term "Type V1-b" indicates that the spectral conditions have been particularized even further. Type V1 refers to the spectral sensitivity of the average normal human eye, a representative curve for which has been standardized by the International Commission on Illumination. The "b" in Type V1-b refers to the spectral energy distribution of the incident radiant flux and indicates that the spectral quality is that of a tungsten lamp operating at a colour (distribution) temperature of 3 000 K.

Similarly, in the second classification, the term "printing" is used to indicate that the receiver of the transmitted flux is either the photographic printing material or has a spectral sensitivity equal to it. Type 2, used in connection with printing density, refers to a spectral-sensitivity curve representative of commonly used photographic printing papers. This spectral sensitivity is specified in detail in this International Standard. The "b" in Type P2-b again refers to the spectral energy distribution of the incident radiant flux and indicates that the spectral quality is that of a tungsten lamp operating at a colour (distribution) temperature of 3 000 K.

"Diffuse photoelectric density" and "diffuse spectral density"¹⁾ (diffuse density for a single wavelength) designate other spectral classes of diffuse density which are not covered in detail in this International Standard. These spectral classes of density are, however, important in certain practical work. Their relation to this International Standard is described in the annex and illustrated in figure 12.

0.2 Calibration of practical densitometers

With the establishment of this International Standard it becomes practicable to calibrate a number of photographic samples by one of the approved measuring methods and to use these as reference specimens for calibrating ordinary densitometers.

In general only those densitometers which conform to the geometric and spectral conditions specified in this International Standard are capable of giving accurate readings of ISO Standard diffuse visual density or ISO Standard diffuse printing density for all types of photographic materials. However, many simple densitometers give readings on different photographic materials with sufficient accuracy for most practical work. The scope of such instruments can be tested by measuring samples which vary in scattering power and in spectral selectivity and comparing these results with those obtained by the appropriate recommended method.

1) See Report of Committee on Colorimetry, *Journal of the Optical Society of America*, 34, 4, 188, Section 8, "Transmittance, Opacity and Density".

If a nonconforming densitometer is to be used for a large amount of routine work in connection with a given type of photographic material, it may be calibrated from reference samples or a reference wedge composed of the same material. In this way any type of densitometer can be calibrated to read ISO Standard diffuse visual density or ISO Standard diffuse printing density for any single type of photographic material, to a degree of accuracy commensurate with the stability and reproducibility of the instrument itself. In general, a new calibration must be made if accurate readings are desired on a different photographic material when a nonconforming densitometer is used.

1 SCOPE AND FIELD OF APPLICATION

This International Standard defines diffuse transmission density and specifies techniques for its measurement.

It applies primarily to processed black-and-white photographic films and plates, although it can also be applied to other radiation-absorbing media such as cast colloidal carbon-gelatin tablets or filters, filters consisting of dyes in gelatin, glass filters, or various types of radiation-absorbing screens used in photographic work where diffuse-density measurements are desired.

2 GENERAL DEFINITION OF DENSITY

Density is defined in general terms as the logarithm of the ratio of the radiant flux P_0 incident on the sample to the radiant flux P_t transmitted by the sample.

$$D = \log \left(\frac{P_0}{P_t} \right) \quad \dots (1)$$

3 TOTALLY DIFFUSE DENSITY

3.1 Definition

Totally diffuse density is defined by the expression in clause 2 when the following conditions are fulfilled :

3.1.1 Geometric conditions

3.1.1.1 The incident radiant flux shall be normal (at an angle of 90°) to the plane of the sample and all of the transmitted radiant flux shall be collected and equally evaluated; or the incident radiant flux shall be perfectly diffuse and only the normally transmitted component shall be collected and evaluated.

3.1.1.2 The effects of reflections between the sample and parts of the apparatus (cover glasses, surfaces of the illuminator or collector, etc.) shall be negligible.

3.1.1.3 Stray radiation shall be negligible.

3.1.2 Spectral conditions

Any spectral conditions may be associated with totally diffuse density. The geometric conditions can usually be fulfilled independently of the spectral conditions. If the sample is spectrally nonselective, the specification of the geometric conditions is sufficient for the unique evaluation of density.

4 ISO STANDARD DIFFUSE DENSITY

4.1 Definition

The term "ISO Standard diffuse density" designates densities determined under the practical geometric conditions provided by any one of the following three standard means and methods. These conditions approach the ideal conditions for totally diffuse density given in 3.1.1 as closely as practical equipment and methods permit.

4.1.1 The integrating sphere method is described in detail in clause 7.

4.1.2 The opal glass method is described in detail in clause 8.

4.1.3 The contact printing method is described in detail in clause 9.

4.2 Spectral conditions

Any spectral conditions may be associated with ISO standard diffuse density.

5 ISO STANDARD DIFFUSE VISUAL DENSITY

5.1 Definition

ISO Standard diffuse visual density, Type V1-b, is a particular spectral type of ISO Standard diffuse density and is defined by the expression in 4.1 when the following spectral conditions are fulfilled :

5.1.1 The product of the relative spectral sensitivity of the receiver of the radiant flux times the relative energy of the incident radiant flux at each wavelength shall be proportional to the product of the sensitivity and energy given in logarithmic form in column 4 of table 1.

5.1.2 The tolerances on the spectral characteristics of the system shall be such that the resulting numerical values of density will not be significantly different from those which would be obtained if the spectral requirements were perfectly met.¹⁾

5.1.3 The relative sensitivity values given in logarithmic form in column 2 of table 1 are those adopted by the International Commission on Illumination, for the average normal human eye adapted to photopic vision.

5.1.4 The relative energy values given in logarithmic form in column 3 of table 1 are for a tungsten lamp operating at a colour (distribution) temperature of 3 000 K.

5.1.5 These requirements permit the use of filters in combination with various sources and receivers provided that the overall spectral characteristics of the combination conform with those specified in column 4 of table 1.

TABLE 1 — Spectral conditions for
ISO Standard diffuse visual density
Type V1-b

1	2	3	4
Wavelength nm	log (Relative sensitivity*)	log (Relative energy)	log (Relative sensitivity times energy)
400	0,00	0,00	0,00
420	1,00	0,14	1,14
440	1,76	0,27	2,03
460	2,18	0,38	2,56
480	2,54	0,47	3,01
500	2,91	0,56	3,47
520	3,25	0,63	3,88
540	3,38	0,70	4,08
560	3,40	0,76	4,16
580	3,34	0,81	4,15
600	3,20	0,86	4,06
620	2,98	0,90	3,88
640	2,64	0,94	3,58
660	2,18	0,97	3,15
680	1,63	1,00	2,63
700	1,01	1,02	2,03

* For the purposes of this International Standard the relative spectral sensitivity of the receiver is defined in general terms as the reciprocal of the relative energy necessary to produce a given response.

1) When the samples are spectrally nonselective, the product of the energy of the source and the sensitivity and energy of the receiver and source actually used is not critical and may depart widely from values given in the column headed "log relative sensitivity times energy" given in table 1 without significantly affecting the results. Since photographic films and plates developed in ordinary, nonstaining developers are often sufficiently nonselective, the spectral conditions given in table 1 need not be in close agreement with the ideal values. However, the measurement of the effective density of a sharp-cutting yellow colour filter, for example, will require relatively close agreement with the ideal spectral values given in table 1.

6 ISO STANDARD DIFFUSE PRINTING DENSITY

6.1 Definition

ISO Standard diffuse printing density, Type P2-b, is one spectral type of ISO Standard diffuse density and is defined by the expression in 4.1 when the following spectral conditions given in 6.1.1 are fulfilled.

6.1.1 The product of the relative spectral sensitivity of the receiver of the radiant flux at each wavelength times the relative spectral-energy distribution of the radiant flux incident on the sample shall be proportional to the product of sensitivity and energy given in logarithmic form in the last column of table 2.

6.1.2 The tolerance on the log relative sensitivity times energy values in column 4 of table 2 shall be such that the resulting numerical values of density will not be significantly different from those which would be obtained if the spectral requirements were perfectly met.

6.1.3 The relative sensitivity values given in logarithmic form in column 2 of table 2 will be the logarithm of the product of an average of the relative spectral sensitivities of commonly used photographic printing materials times the transmission of an ultra-violet absorbing filter which has a sharp cut-off at 360 nm. The filter has been included in order to minimize errors which might arise because of the uncertain transmission of glass optics at short wavelengths and the transmission band of silver deposits at 320 nm.

6.1.4 The log relative energy values given in column 3 of table 2 are for a tungsten lamp operating at a colour (distribution) temperature of 3 000 K.

6.1.5 The use of filters in combination with various sources and receivers is permissible provided the overall spectral characteristics of the combination conform with those given above.

6.1.6 The integrating sphere method (see clause 7) and opal glass method (see clause 8) actually measure **simulated** ISO Standard diffuse density. The contact printing method (see clause 9) is a **direct** method for measuring ISO Standard diffuse printing density (not simulated).

When the requirements of this International Standard are followed for integrating sphere and opal glass measurements, the resulting values of printing density (simulated) will be equal to those that can be obtained directly using the contact printing method. However, in the interest of simplicity, the word "simulated" has not been used throughout this International Standard when referring to printing density measurements made using the integrating sphere and opal glass methods.