

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 5

PHOTOGRAPHY — DETERMINATION OF DIFFUSE TRANSMISSION DENSITY (PHOTOGRAPHY)

1st EDITION

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BRIEF HISTORY

This ISO Recommendation R5 was prepared by Technical Committee ISO/TC 42 — Photography, the Secretariat of which is held by the American Standards Association, Inc. (ASA).

In April 1948, the Secretariat asked the General Secretariat to submit, as a Draft Proposal, for study by the Technical Committee, the American Standard Z 38.2.5 — 1946, concerning diffuse transmission density. This Draft Proposal was distributed on 12 May, 1948, to all the Members of the Technical Committee. In view of the fact that no observations were received, the Secretariat considered the Draft Proposal as adopted by the Technical Committee as a Draft ISO Recommendation.

In January 1951, this Draft ISO Recommendation was submitted to the ISO Member Bodies by the General Secretariat. Out of 29 ISO Member Bodies, the following 17 sent in their approval:

Australia	Mexico	Switzerland
Austria	Netherlands	Union of South Africa
Belgium	New Zealand	United Kingdom
Czechoslovakia	Poland	U.S.A.
Finland	Portugal	Yugoslavia.
Italy	Sweden	

The following 2 Member Bodies stated that they had no objection to the approval of the Draft:

Denmark
France

The ISO/TC 42 Secretariat amended the Draft, taking account of the observations made by various Member Bodies.

The revised text was then submitted by correspondence to the ISO Council Members who decided, in May 1954, to accept it as an ISO RECOMMENDATION.

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, and Addendum

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

Australia	Mexico	Switzerland
Austria	Netherlands	~~Union of South Africa~~
Belgium	~~New Zealand~~	United Kingdom
Czechoslovakia	Poland	U.S.A.
Finland <i>Denmark</i>	Portugal	Yugoslavia.
Italy <i>France</i>	Sweden <i>South Africa Rep. of</i>	

The Member Bodies of the following countries have subsequently approved this Recommendation :

~~The Member Body of the following country expressed disapproval of the Recommendation on technical grounds :~~

★

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

~~* Subsequently, this Member Body approved the Recommendation.~~

DIFFUSE TRANSMISSION DENSITY (PHOTOGRAPHY)

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PHOTOGRAPHY - DETERMINATION OF DIFFUSE TRANSMISSION

0 ← INTRODUCTION

Density

0.1 Discussion of ^e 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 color quality of the light and the color 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) ~~Geometric~~ Specification of the geometric characteristics of the optical system used in the measurement.

(b) ~~Spectral~~ 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 ~~Appendix annex.~~ This I... S...

~~The present recommendation~~ is concerned only with diffuse density. This type of density is closely related to many practical applications of photographic materials (see ~~Appendix~~). 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. ~~The present recommendation~~ provides a definition (see ~~Section~~ 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 ~~Recommended~~ diffuse density" has been chosen to designate densities which have been determined under the practical geometric conditions provided by the apparatus and methods ~~described~~ in ~~specified~~

the annex

This I... S...
clause

Standard

I...S...O *specified*
 this ~~recommendation~~. The ~~recommended~~ 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 ~~prescribed~~ in this ~~recommendation~~. *I...S...O* *specified*

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, ~~the present recommendation~~ 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 ~~Appendix~~

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 ~~fixed~~ 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 ~~recommendation~~. The "b" in Type P2-b again refers to the spectral energy distribution of

colour (distribution)

the incident radiant flux and indicates that the spectral quality is that of a tungsten lamp operating at a ~~fixed~~ 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 ~~the present recommendation~~. These spectral classes of density are, however, important in certain practical work. Their relation to ~~the present recommendation~~ is described in the ~~Appendix~~ and illustrated in figure 12.

0.2 Calibration of practical densitometers With the establishment of this ~~recommendation~~ 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 ~~recommendation~~ are capable of giving accurate readings of ISO ~~Recommended~~ diffuse visual density or ISO ~~Recommended~~ 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.

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 ~~Recommended~~ diffuse visual density or ISO ~~Recommended~~ 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.

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

I...S...O

colour (distribution)

This I...S...O P1 this I...S...O annex

I...S...O

I...S...O Standard

Standard

ISO Recommendation for Diffuse Transmission Density

1/ Scope AND FIELD OF APPLICATION

The principal purpose of this recommendation is to define diffuse transmission density and specify 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 Section 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 Recommended Diffuse Density

4.1 Definition

The term "ISO Recommended diffuse density" designates densities determined under the practical geometric conditions provided by any one of the following three

means and methods. These conditions approach the ideal conditions for totally diffuse density given in Section 3.1.1 as closely as practical equipment and methods permit.

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

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

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

4.2 Spectral conditions Any spectral conditions may be associated with ISO Recommended diffuse density.

5/ ISO Recommended Diffuse Visual Density

5.1 Definition ISO Recommended diffuse visual density, Type V1-b, is a particular spectral type of ISO Recommended diffuse density and is defined by the expression in Section 4.1 when the spectral conditions which 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.

TABLE 1
Spectral Conditions for
ISO Recommended Diffuse Visual Density
Type V1-b

1 Wave-length nm	2 log (Relative Sensitivity*)	3 log (Relative Energy)	4 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 recommendation 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.