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Fotografija - Merjenje optične gostote - 3. del: Spektralni pogoji (kanalna občutljivost)

Photography -- Density measurements -- Part 3: Spectral conditions

Photographie -- Mesurage des densités -- Partie 3: Conditions spectrales

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Photography — Density measurements —

Part 3:
Spectral conditions

Photographie — Mesurage des densités —

Partie 3: Conditions spectrales

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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 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 5-3 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 5-3:1984), which has been technically revised. It has also been expanded to include additional spectral types commonly used in consumer, professional, and graphic arts photographic applications. Status E and status I responses have been included in view of their relevance to graphic technology.

Annexes A to D of this part of ISO 5 are for information only.

Introduction

This part of ISO 5 is one of a series which specifies the spectral conditions for optical densitometry as practised in black-and-white and colour photographic applications.

To define a density value fully, it is necessary to specify both the geometric and spectral conditions of the measuring system. Geometric conditions are described in ISO 5-2 for transmission density, and in ISO 5-4 for reflection density. This part of ISO 5 specifies the spectral conditions for both transmission and reflection density measurements.

In the early years of densitometry, the spectral responses of instruments were specified only in terms of the colour filters used in the construction. Although it was seldom the case, it was assumed that the spectral responses of the photoreceivers and the illuminant spectral energy distributions as well as all intervening optical components were the same in all instruments. In more recent times densitometry standards have specified that the product of all these components must equal some given set of published "documentary" values. Such a specification allows flexibility to the manufacturer while providing for improved accuracy and precision. It also allows for standard reference materials to be manufactured and certified based on fundamental measurements.

In photographic image reproduction, optical density is a measure of the modulation of light or other radiant flux by a given area of the recording medium. The measurement of density may be of interest for various reasons. It may be necessary to assess the lightness or darkness of an image, to predict how a film or paper will perform in a printing operation, or to determine some measure of the amounts of colorants in the image for the purpose of controlling a colour process. If the visual effect is of interest, the spectral conditions of measurement must simulate some appropriate illumination and the spectral sensitivity of the eye. For printing operations, the spectral power distribution of the irradiator to be used in the printing operation and the spectral sensitivity of the print material must be simulated. In evaluating original material for colour separation, the illuminant, the spectral sensitivity of the separation medium, and the spectral transmittance of the tricolour separation filters must be simulated.

Certain types of density measurements are often made to generate sensitometric curves which are used to characterize the photographic properties of films and papers. Densities can also be used for tone-reproduction analysis and to monitor various operations such as photoprocessing, lithography, gravure, screen printing processes, etc.

The specified spectral power distribution of the incident flux for transmission density measurements differs from that for reflection density measurements. For reflection density measurements, incandescent tungsten illumination of the type known as CIE (Commission internationale de l'éclairage) standard illuminant A, adopted by the International Commission on Illumination in 1931 is specified. Its use in densitometry is preferred because national standardizing laboratories are generally prepared to make spectrophotometric measurements and perform colorimetric computations of visual reflection factors on the basis of CIE standard illuminant A. This usage facilitates the procurement of physical standards for reflection densitometry. For transmission density measurements, the spectral distribution of the influx is CIE standard illuminant A, as modified by a typical heat-absorbing filter to protect the specimen and optical system from heat.

Many standards for reflection density specify the use of barium sulfate as the reference standard. However, pressed barium sulfate is fragile, variable from lot to lot of powder, variable from pressing to pressing, and the reflectance drifts appreciably in the first few days after pressing.

In 1969, the International Commission on Illumination (CIE) recommended that all reflectance factors and, by inference, the corresponding reflection densities be reported relative to a perfectly reflecting and perfectly diffusing material.

In day-to-day operation reflection densitometers are usually calibrated with standard reference materials available from a number of sources. These working standards are calibrated with respect to primary standards that are calibrated by absolute methods in national standards laboratories.

Photography — Density measurements —

Part 3:
Spectral conditions

1 Scope

This part of ISO 5 specifies spectral conditions for the measurement of several types of densities used in photographic image reproduction. Photographic image reproduction as used throughout this part of ISO 5 encompasses the broad definition of photography as the art or process of producing images on a sensitized surface by the action of radiant energy.

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.*

CIE Publication 17.4:1987, *International lighting vocabulary.*

CIE Publication 18.2:1983, *The basis of physical photometry.*

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 CIE standard illuminant A: Planckian radiation at a temperature of about 2 856 K.[1)]

NOTES

1 Based on the International Practical Temperature Scale, 1968, using Planck's second constant
$c_2 = 1{,}438\,8 \times 10^{-2}$ m·K

2 The radiation of a gas-filled coil tungsten filament lamp operated at a distribution temperature of 2 856 K will approximate this spectral distribution and thus can serve as a practical realization of this standard illuminant.

3.2 sideband rejection: The degree that radiation outside a desired passband is blocked or suppressed. It is usually expressed as the ratio of the integrated energy within the desired passband to the integrated energy outside the passband.

3.3 peak wavelength: That wavelength at which the system response is a maximum.

3.4 spectral bandwidth: Width, in wavelength units, of the response band measured between the points where the response has fallen to designated percentages of the peak response.

3.5 influx spectrum: Spectrum of the radiant flux incident on the specimen surface or sampling aperture. It is a function of the energy source and the optical system on the source side of the specimen.

4 Density measurements

To define completely a type of density spectrally, it is necessary to specify the light source, optics and spectral response of the measuring system.

The basic light source for densitometry is CIE standard illuminant A (see 3.1). In some reflection and almost all transmission densitometers, it is necessary to add a heat-absorbing filter to the influx side to protect the specimen and optical elements. If the ab-

1) As defined in CIE Publication 17.4.

sorber does not change the relative power distribution of CIE A below 550 nm, no significant fluorescence effect should be observed or be of concern.

4.1 Reflection densitometry

For reflection density measurements, if either the densitometer manufacturer or the user is not sure of the absence of fluorescence in the sample to be measured, the relative spectral power distribution of the incident flux shall be CIE standard illuminant A which is given in table 1 under the heading S_A (which is the symbol used in functional notation).

4.2 Transmission densitometry

For transmission density measurements, if either the densitometer manufacturer or the user is not sure of the absence of fluorescence in the sample to be measured, the relative spectral power distribution of the incident flux shall be that given in table 1 under the heading S_H (which is the symbol used in functional notation). This is based on the spectral power distribution of the CIE standard illuminant A modified in the infrared region to protect the sample and optical elements from excessive heat which is typical for most transmission densitometers.

4.3 Sample conditions

Some materials change density with variations in temperature and relative humidity. Therefore, to avoid ambiguity, specimens shall be at 23 °C ± 2 °C and (50 ± 5) % relative humidity when determining ISO density.

5 Spectral response, s

The spectral response of a densitometer is a function of the spectral sensitivity of the photodetector and the spectral modifications by any of the optics and filters between the plane of the specimen and the photodetector. Theoretically, it is desirable for the spectral response to match the spectral sensitivity of the receiver (eye, photographic paper, etc.) used in the practical applications of the product.

6 Spectral products, Π

If the spectral power of the influx spectrum, S, is multiplied by the spectral response, s, of the receiver, wavelength by wavelength, spectral products are obtained. Since significant fluorescence from a number of sources is often encountered, it is desirable to conform to the influx spectra specified in this part of ISO 5. However, in those cases where there is no fluorescence in the specimen or in the optical elements, it is not necessary to specify the spectral characteristics of the influx and receiver separately, as long as the correct spectral products are obtained. The spectral products for a densitometer may be denoted as:

$$\Pi = Ss$$

where

S is the relative spectral power of the influx;

s is the relative spectral response of the receiver, which includes the photodetector and all intervening components between it and the plane of the specimen.

7 Notation

ISO 5-1 specifies functional notation of the form $D(G; S : g; s)$, where G and g symbolize the influx geometry and efflux geometry respectively. Since this part of ISO 5 is only concerned with spectral conditions, the notation is abbreviated to $D(S : s)$. To distinguish between reflection density (D_R) and transmission density (D_T), a subscript may be used.

8 Types of density

Several spectral types of densitometry are used to evaluate photographic recording media. These are defined in terms of logarithmic spectral product values specified at 10 nm (nanometre) intervals. Spectral product, Π, values are obtained by multiplying the relative spectral power values of the densitometer influx spectrum, S, at 10 nm intervals by the relative spectral response values, s, of the receiver in the pertinent wavelength region. The resultant products are normalized to yield a peak value of 100 000. The logarithms to the base 10 of these values are used in this part of ISO 5 to define the various spectral types.

8.1 ISO visual density, $D_T(S_H : V_T)$, $D_R(S_A : V)$

To evaluate the darkness of an image which is to be viewed directly or by projection, visual density is measured. Such measurements are most often made on black-and-white images, but can be made on other types of images.

For reflection density, the combined spectral sensitivity of the receiver and the spectral characteristics of the components of the efflux section of the densitometer shall match the spectral luminous efficiency function for photopic vision, $V(\lambda)$.[2] The product of $V(\lambda)$ and S_A, wavelength by wavelength, defines the spectral products the whole densitometer must have in order to provide ISO visual densities. The logarithms of the products are given in table 2.

2) See CIE Publication 18.2.

Table 1 — ISO densitometer influx spectra

Wavelength λ, nm	Transmission densitometer influx spectrum S_H	Reflection densitometer influx spectrum S_A
340	4	4
350	5	5
360	6	6
370	8	8
380	10	10
390	12	12
400	15	15
410	18	18
420	21	21
430	25	25
440	29	29
450	33	33
460	38	38
470	43	43
480	48	48
490	54	54
500	60	60
510	66	66
520	72	72
530	79	79
540	86	86
550	93	93
560	100	100
570	107	107
580	111	114
590	115	122
600	116	129
610	119	136
620	117	144
630	113	151
640	107	158
650	102	165
660	96	172
670	89	179
680	80	185
690	72	192
700	62	198
710	53	204
720	45	210
730	37	216
740	31	222
750	24	227
760	19	232
770	15	237

NOTE — Relative spectral power distributions are normalized to 100 at 560 nm.