International Standard ISO 3028

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Photography — Camera flash illuminants — Determination of ISO spectral distribution index (ISO/SDI)

Photographie — Illuminant type «lampe éclair» pour photographie — Détermination de l'indice de distribution spectrale ISO (ISO/SDI)

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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.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 3028 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 3028 was first published in 1974. This second edition cancels and replaces the first edition, of which it constitutes a fundamental revision.

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Photography — Camera flash illuminants — Determination of ISO spectral distribution index (ISO/SDI)

0 Introduction

This International Standard specifies a method for evaluating the colour quality of flash illuminants used in photography. This revision of ISO 3028 was considered necessary in order to recognize the spectral sensitivity of colour films as they are presently manufactured. It also utilizes the recently approved spectral transmittance values of the ISO standard camera lens (see ISO 6728). For these reasons, spectral distribution indexes (SDI) determined according to this edition of ISO 3028 shall not be compared with those of the previous edition.

Camera flash units are generally used indoors for exposing film which has been specifically designed to provide optimum results outdoors in daylight. Therefore, flash units should give results with an overall colour balance equivalent to that obtained in daylight (see ISO 7589). The ISO/SDI of a flash source, determined according to this International Standard, is a numerical expression of the colour balance shift expected in flash pictures compared with those taken in natural daylight. It is expected that this International Standard will be used by manufacturers in the design and control of photographic light illuminants.

This International Standard is intended primarily to evaluate electronic flash units and expendable sources such as flash bulbs. However, it may also be used to evaluate any illuminant under which daylight-type colour films are exposed.

1 Scope and field of application

This International Standard specifies a method for calculating a spectral distribution index (SDI) to evaluate the ability of expendable flash and electronic flash units to produce photographic colour results comparable to those obtained with daylight-type films exposed to daylight illumination.

2 References

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

ISO 6728, *Photography — Camera lenses — Determination of ISO colour contribution index (ISO/CCI).*

ISO 7589, *Photography, — Illuminants for sensitometry — Specifications for daylight and incandescent tungsten.*

CIE Publication No. 15, *Colorimetry, Official Recommendations of the International Commission on Illumination.*

3 Definitions

For the purpose of this International Standard, the terms listed in ISO 5/1 and the following apply:

3.1 source: A physical emitter of energy.

3.2 illuminant: Light having a specific spectral power distribution not necessarily provided directly by a source and not necessarily realizable by a source.

3.3 relative spectral power distribution: A description of the spectral character of radiation by the relative distribution of some radiometric quantity (radiant flux, radiant intensity).

3.4 photographic response R**:** The effective response of a sensitized photographic material to radiant flux.

This can be represented by the equation

$$R = \int_{\lambda_1}^{\lambda_2} S_\lambda \, s(\lambda) \, \tau(\lambda) \, \mathrm{d}\lambda \qquad \ldots (1)$$

where

R is the photographic response;

S_λ is the relative spectral power distribution of the radiant flux;

$s(\lambda)$ is the relative spectral sensitivity of the camera film or paper;

$\tau(\lambda)$ is the axial relative spectral transmittance of the camera lens (or optical system);

λ is the wavelength;

λ_1 to λ_2 is the range of wavelengths over which the photographic material is sensitive.

3.5 spectral sensitivity of film: The reciprocal of the amount of power required at each wavelength to produce a specified density in the final image.

3.6 weighted spectral sensitivity values: Obtained by combining the relative spectral sensitivity of the material and relative spectral transmittance values for the ISO standard camera lens to simplify the determination of spectral distribution index values.

3.7 spectral distribution index; SDI: A three number designation which describes the degree to which a light source is expected to change the overall colour of a photograph relative to that obtained with a specified illuminant. In this International Standard, photographic daylight is used as the reference.

3.8 photographic daylight: The relative spectral power distribution of typical daylight having a correlated colour temperature of approximately 5 500 K. This describes the combination of skylight and sunlight when the sun is about 40° above the horizon with a clear atmosphere, and is designated as D_{55}.

4 Method of test

4.1 Principle

The SDI of a flash illuminant is calculated from its relative spectral power distribution values and the weighted spectral sensitivity values provided in this International Standard.

4.2 Illuminants

4.2.1 Photographic daylight: Most camera colour films are designed to produce optimum results with photographic daylight illumination. The spectral power distribution of daylight varies with time of day, geographical location, and the orientation of the illuminated surface.

Extensive radiometric measurements were made for five different conditions of daylight normally encountered. Data corresponding to a correlated colour temperature of about 5 500 K were selected as the most appropriate for photography and designated D_{55} [1]. This is the prevailing condition in temperate zones during the daylight hours recommended for colour photography. The relative spectral power distribution for D_{55} is given in table 1 and used as a reference in this International Standard.

4.2.2 Flash illuminants

The ideal flash source for exposing colour films balanced for daylight would have the same relative spectral power distributions as daylight illumination D_{55} at all wavelengths. While this is not achievable in practice, even when filters are employed in combination with a basic flash source, illuminants can be designed to produce the same general photographic effect as obtained from D_{55}. An evaluation of any divergence in photographic effect must consider the spectral sensitivity of films and the spectral transmittance of camera lenses.

Table 1 — Spectral data

Wavelength, λ	Relative spectral transmittance of the ISO standard lens	Relative spectral power distribution of daylight[2] D_{55}
nm	$\overline{\tau}(\lambda)$	
350	0,00	28
360	0,07	31
370	0,23	34
380	0,42	33
390	0,60	38
400	0,74	61
410	0,83	69
420	0,88	72
430	0,91	68
440	0,94	86
450	0,95	98
460	0,97	100
470	0,98	100
480	0,98	103
490	0,99	98
500	0,99	101
510	1,00	101
520	1,00	100
530	1,00	104
540	1,00	102
550	1,00	103
560	1,00	100
570	1,00	97
580	1,00	98
590	0,99	91
600	0,99	94
610	0,99	95
620	0,98	94
630	0,98	90
640	0,97	92
650	0,97	89
660	0,96	90
670	0,95	94
680	0,94	90
690	0,94	80

Flash illuminants are usually designed to produce the same result as daylight using a non-selective neutral test object. This will generally produce excellent pictures. However, the greater the flash spectrum deviates from that of D_{55}, the greater is the potential for error in the colour reproduction for spectrally selective objects. Also, even though a flash source is balanced to give the same result as daylight for non-selective neutral objects on average daylight film according to this International Standard, specific film products may show significant colour balance shifts if their spectral sensitivities differ significantly from the average values used in this International Standard.

1) JUDD, D.B., MACADAM, D.L., WYSZECKI, G. Spectral distribution of typical daylight as a function of correlated color temperature. *Journal of the Optical Society of America* 54(8) 1964: 1031-1040.

2) CIE Publication No. 15 (E-3.1.3).

4.2.2.1 Temporal considerations. The spectral quality of a flash source is a function of time. The time interval over which the film is exposed may be limited either by closing the shutter or quenching the electronic flash when sufficient radiant energy has been detected by a photocell. In some cases, exposure time duration can be significantly shorter than the duration of the flash, particularly when taking close-up pictures. This makes it necessary to consider the temporal aspects of the flash spectrum to characterize its spectral power distribution properly for use in this International Standard.

4.2.2.2 Spectroradiometric measurements. Measurement of the relative spectral power distribution of a flash source shall be accurately made at bandwidths of 10 nm or less from 360 to 680 nm. The values determined and used shall be for the wavelengths specified in this International Standard.

4.3 Weighted spectral sensitivity values

4.3.1 Lens transmittance

The spectral transmittance of a camera's optical system, including such elements as lenses, mirrors and filters over the wavelength interval to which daylight-type film has significant sensitivity must be considered in evaluating illuminants. Since a lens is the only element in the optical taking system of most cameras, its characteristics are of primary interest in standardization. However, if additional items such as mirrors are used in the optical path of the imaging system, their spectral selectivity must be considered together with that of the lens.

The average axial relative spectral transmittance characteristics of 57 typical lenses as found in medium and high priced cameras were determined by a survey in 1979 and are referred to as those of an ISO standard camera lens. The spectral transmittance values for this lens are given in table 1 and used as a basis for this International Standard.

4.3.2 Spectral sensitivity of colour film

Colour films consist of layers, each with its own spectral sensitivity. Some layers will be primarily sensitive to blue light, while others will have primary sensitivity in the green or red regions. Since colour films differ in their relative spectral sensitivity, the effective colour of an illuminant depends on the film used for evaluation.

During 1977, manufacturers worldwide were requested to supply average spectral sensitivity data for their daylight type camera colour sensitized materials used in pictorial photography. Data from four manufacturers were received and averaged. These average values are used as references in this International Standard. Average relative spectral sensitivity values, $\bar{s}(\lambda)$, for the blue, green, and red sensitive layers, each normalized to a peak of 100, are given in table 2.

Table 2 — Average colour-film relative spectral sensitivity $\bar{s}(\lambda)$

(The sensitivity of each layer is normalized to a peak of 100.)

Wavelength, λ nm	Blue $\bar{s}_B(\lambda)$	Green $\bar{s}_G(\lambda)$	Red $\bar{s}_R(\lambda)$
350	2		
360	5		
370	12		
380	26		
390	49	1	
400	71	1	
410	87	1	
420	97	1	
430	100	1	
440	87	1	
450	80	1	
460	68	1	
470	47	2	
480	25	3	
490	11	6	
500	4	9	
510	3	14	
520	1	20	
530		31	1
540		60	1
550		100	2
560		51	3
570		54	5
580		39	7
590		11	12
600		2	19
610			26
620			34
630			54
640			83
650			100
660			70
670			17
680			2

NOTE — Reciprocity law failure of a film can be responsible for shifts in colour balance and speed as exposure time is changed. An attempt is made on the part of film manufacturers to minimize such effects. There is no satisfactory method for accomodating this variable for an average film, but it should be recognized as a factor when extremely short exposure times are involved, i.e. close-up pictures with self-quenching electronic flash or when long exposure times are used.