INTERNATIONAL STANDARD

ISO 7589

Second edition
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Photography — Illuminants for sensitometry — Specifications for daylight, incandescent tungsten and printer

Photographie — Illuminants sensitométriques — Spécifications pour la lumière du jour, la lumière artificielle et la tireuse

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 7589 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 7589:1984), which has been technically revised and enlarged to include a standard sensitometric illuminant for black-and-white papers.

Annexes A to D of this International Standard are for information only.

Introduction

Colour and black-and-white camera films are most commonly designed for use with three light sources, these being daylight, studio tungsten (type B) and photoflood (type A), while black-and-white papers are most commonly used with enlargers employing incandescent tungsten sources. This International Standard specifies three corresponding illuminants for film sensitometry and one for black-and-white paper sensitometry, since most meaningful results are obtained when exposing conditions match those of actual film or paper use. Two other important photographic light sources for film, the electronic flashtube and blue photoflash lamps, give light of a colour that approximates daylight so that the sensitometric daylight illuminant also serves for films used with them.

This International Standard constitutes a revision of the first edition, ISO 7589:1984. It differs from the first edition in that it includes a standard sensitometric illuminant for black-and-white papers (the first edition dealt with camera film illuminants only). No standard exists for the determination of the speeds of colour papers.

The illuminants described in this International Standard are used in ISO 3028, ISO 6728 and other International Standards which describe methods for determining the speed of various types of sensitized products.

Photography — Illuminants for sensitometry — Specifications for daylight, incandescent tungsten and printer

1 Scope

This International Standard specifies the spectral characteristics of illuminants for sensitometry appropriate for evaluating camera films used for pictorial photography in natural daylight, studio tungsten and photoflood, including colour and black-and-white films, both reversal and negative types, and for evaluating black-and-white papers used with incandescent tungsten printers. It also describes methods for evaluating the acceptability of illuminants for sensitometry and specifies tolerances.

It does not include illuminants for use with colour papers, since this would need to take account of the coloured mask of the negative material, for which no standard information is at present available.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3028:1984, *Photography — Camera flash illuminants — Determination of ISO spectral distribution index (ISO/SDI)*

ISO 6728:1983, *Photography — Camera lenses — Determination of ISO colour contribution index (ISO/CCI)*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
source
physical emitter of energy

3.2
illuminant
light impinging on a sensitized material and 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
description of the spectral character of radiation by the relative spectral distribution of some radiometric quantity (radiant flux, radiant intensity)

3.4
distribution temperature
thermodynamic temperature of the full radiator for which the ordinates of the spectral distribution curve of its radiance are proportional, in the visible region, to those of the distribution curve of the radiation considered

3.5
photographic daylight
relative spectral power distribution of typical daylight having a correlated colour temperature of approximately 5 500 K

NOTE 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}.

3.6
spectral distribution index
SDI
three-number designation for camera films 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, and two-number designation for black-and-white enlarging papers which describes the degree to which a light source affects the relative contributions from emulsion sensitivity and dye sensitivity

4 ISO sensitometric illuminants

4.1 General

This International Standard is concerned with the simulation of the spectral quality of radiation incident on the film (not the camera) or on the enlarger baseboard (not the enlarger lamp).

In order to realize this simulation, a given *photographic* illuminant (which is concerned with the light illuminating the subject matter or the light before passing through the optical system of a printer) has to be suitably modulated. For the purposes of this International Standard, the ISO standard camera lens specified in ISO 6728 has been taken as the best available modulator for which standard data are available.

The relative spectral power distributions of the four ISO sensitometric illuminants described in this International Standard are normally obtained by operating a lamp at a specified condition and modulating the flux with selectively absorbing filters of suitable spectral transmittance. It should be emphasized that this International Standard specifies the relative spectral distribution of power incident on the exposure plane at 10 nm intervals, i.e. the relative spectral power emitted by a source and its modulation by all elements in the sensitometer that affect the spectral quality, for example filters, mirrors and optical wedge.

4.2 ISO sensitometric daylight illuminant

This is suitable for the sensitometry of “daylight balanced” colour films and is also normally used for black-and-white camera films. These films are designed to be exposed in photographic daylight (see 3.5) or with flash. The spectral power distribution used to represent photographic daylight was taken from the data of Judd *et al*.[4] who give typical spectral irradiance data for five different conditions of daylight (skylight and sunlight plus skylight). Data corresponding to a correlated colour temperature of 5 500 K were selected as the most appropriate for photography and designated as D_{55}. This is the prevailing condition in temperate zones during the daylight hours recommended for colour photography.

The ISO sensitometric daylight illuminant is defined as the product of the spectral power distribution of photographic daylight (D_{55}) and the spectral transmittance of the International Standard camera lens, $\overline{\tau}(\lambda)$. The aim values, S_λ, for the relative spectral power distribution for this illuminant are given in Table 1. An illuminant complying with these values within the tolerances specified in 5.4 may be designated “ISO sensitometric daylight illuminant”.

4.3 ISO sensitometric studio tungsten illuminant

This is suitable for the sensitometry of type B colour films which are normally exposed with lamps described as 3 200 K lamps. However, the effect of lamp age, reflectors, diffusers and general studio conditions is to reduce the average effective distribution temperature to about 3 050 K. The spectral power distribution used to represent studio tungsten was obtained by spectroradiometric measurements in several professional photographic studios. The aim values, S_λ, for the relative spectral power distribution for this source after modulation by the ISO standard lens are given in Table 2. An illuminant complying with these values within the tolerances specified in 5.4 may be designated “ISO sensitometric studio tungsten illuminant”.

4.4 ISO sensitometric photoflood illuminant

This illuminant is suitable for the sensitometry of type A colour films. The spectral power distribution used to represent photoflood lamps is that of a black body at 3 400 K. The aim values, S_λ, for the relative spectral power distribution of this source after modulation by the ISO standard lens are given in Table 3. An illuminant complying with these values within the tolerances specified in 5.4 may be designated “ISO sensitometric photoflood illuminant”.

4.5 ISO sensitometric printer illuminant

This illuminant is suitable for the sensitometry of black-and-white continuous-tone papers. The spectral power distribution used to represent typical printers is that of a studio tungsten source modified by the ISO standard lens as specified in ISO 6728 and a typical diffusing screen. The aim values, S_λ, for the relative spectral power distribution of this illuminant are given in Table 4. An illuminant complying with these values within the tolerances specified in 6.4 may be designated “ISO sensitometric printer illuminant.”

5 Camera films: Spectral distribution index (ISO/SDI)

5.1 General

The spectral distribution index for camera films is a three-number designation which describes how well a film illuminant matches a specified spectral power distribution in terms of the total photographic responses of the three component emulsions of average colour films. In this International Standard, three different distributions are involved. ISO 3028 gives a more complete description of SDI.

NOTE Other colour imaging systems may exhibit weighted spectral sensitivities similar to those listed in Table 1, 2 or 3. In such a case, the relevant table can be used to calculate SDI values which will estimate illuminant performance.

5.2 Weighted spectral sensitivity values

Weighted spectral sensitivity values for use in evaluating candidate illuminants for acceptability are given in Tables 1, 2 and 3. These values have been weighted so that the aim relative spectral power values for the ISO illuminant in the same table will yield an ISO/SDI of 0/0/0.

5.3 Calculation of the ISO/SDI

The relative spectral power values of a candidate illuminant need to be determined at 10 nm intervals. These values, S_λ, are multiplied by the appropriate blue, green and red weighted spectral sensitivity values $W(\lambda)$. For example, to determine if the illuminant is satisfactory for sensitometric daylight, the weighted spectral sensitivity values in Table 1 would be used. The total photographic responses, R_B, R_G and R_R are obtained by summation $R = \Sigma W(\lambda) S_\lambda$. Logarithms to the base 10 of the total response values are determined to two decimal places. The smallest element of this three-number designation is made equal to zero by subtracting it from all three $\log_{10}$ values. The decimal is eliminated by multiplying by 100. The resultant three numbers are the ISO/SDI for the candidate illuminant. The above calculations are illustrated in Table A.1 for a candidate ISO sensitometric daylight illuminant.

5.4 Tolerances for ISO/SDI

To meet the requirements of this International Standard, the red index shall not differ from the green index by more than ± 3, and the blue index shall not differ from the green index by more than ± 4. These tolerances are depicted in parentheses in Figure 1.

To determine whether an illuminant meets these tolerances, it is recommended that the blue, green and red SDI values be plotted on a trilinear diagram on similar axes to those indicated in Figure 1. This portrays the colour balance of the photographic image obtained with a candidate illuminant compared to that obtained with the illuminant used as a standard.

Calculations for a typical sensitometer set-up that meets the acceptance criterion are illustrated in Table A.1, which shows how to calculate the spectral distribution index. The resultant ISO/SDI 4/2/0 is plotted in Figure 1.

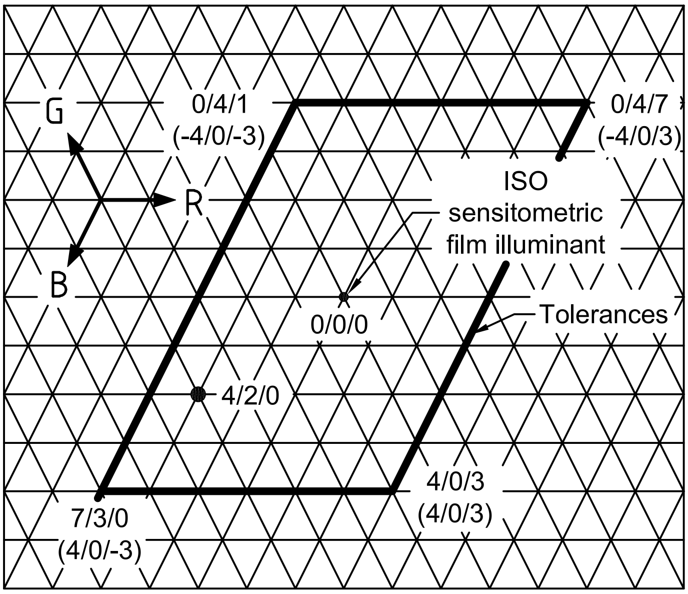

Figure 1 — Trilinear graph for film illuminants

6 Black-and-white papers: Spectral distribution index (ISO/SDI)

6.1 General

The spectral distribution index for black-and-white printing papers is a two-number designation which describes how well a paper illuminant matches the specified spectral power distribution in terms of the total photographic responses of the two sensitivity contributions, emulsion and sensitizing dye, of an average black-and-white enlarging paper.

6.2 Weighted spectral sensitivity values

Weighted spectral sensitivity values for use in evaluating candidate illuminants for acceptability are given in Table 4. These values have been weighted so that the aim relative spectral power values for the ISO sensitometric printer illuminant in the same table will yield an ISO/SDI of 0/0.

6.3 Calculation of the ISO/SDI

The relative spectral power values of a candidate illuminant need to be determined at 10 nm intervals. These values, S_λ, are multiplied by the appropriate emulsion (blue) and dye (blue-green) weighted spectral sensitivity values, $W(\lambda)$ given in Table 4. The total photographic responses R_B and R_G are obtained by summation $R = \Sigma W(\lambda) S_\lambda$. Logarithms to the base 10 of the total response values are determined to two decimal places. The "emulsion" element of this two-number designation is made equal to zero by subtracting it from both $\log_{10}$ values.

The decimal is eliminated by multiplying by 100. The resultant two numbers are the ISO/SDI for the candidate illuminant. The above calculations are illustrated in Table A.2 for a candidate ISO sensitometric printer illuminant.

6.4 Tolerances for ISO/SDI

To meet the requirements of this International Standard, the dye (blue-green) index shall not differ from the emulsion (blue) index by more than ± 4.

Calculations for a typical sensitometer set-up that meets the acceptance criterion are illustrated in Table A.2, which shows how to calculate the spectral distribution index for black-and-white enlarging papers, the resultant ISO/SDI being 0/–2.

Table 1 — Relative spectral power distribution, S_λ, of ISO sensitometric daylight illuminant

Wavelength, λ	Photographic daylight[a] relative power	Relative spectral transmittance of the ISO standard lens	ISO sensitometric daylight illuminant (daylight transmitted by lens)	Weighted spectral sensitivities for calculating ISO/SDI of daylight illuminant		
				Blue	Green	Red
nm	D_{55}	$\bar{\tau}(\lambda)$	$S_\lambda = D_{55}\,\bar{\tau}(\lambda)$	$W_B(\lambda)$	$W_G(\lambda)$	$W_R(\lambda)$
350	28	0,00	0			
360	31	0,07	2,17	1		
370	34	0,23	7,82	2		
380	33	0,42	13,86	5		
390	38	0,60	22,80	9		
400	61	0,74	45,14	14		
410	69	0,83	57,27	17		
420	72	0,88	63,36	19		
430	68	0,91	61,88	19		
440	86	0,94	80,84	17		
450	98	0,95	93,10	15		
460	100	0,97	97,00	13		
470	100	0,98	98,00	9	1	
480	103	0,98	100,94	5	1	
490	98	0,99	97,02	2	1	
500	101	0,99	99,99	1	2	
510	101	1,00	101,00	1	3	
520	100	1,00	100,00		5	
530	104	1,00	104,00		8	
540	102	1,00	102,00		15	
550	103	1,00	103,00		24	1
560	100	1,00	100,00		12	1
570	97	1,00	97,00		13	1
580	98	1,00	98,00		10	2
590	91	0,99	90,09		3	3
600	94	0,99	93,06		1	5
610	95	0,99	94,05			7
620	94	0,98	92,12			9
630	90	0,98	88,20			14
640	92	0,97	89,24			21
650	89	0,97	86,33			26
660	90	0,96	86,40			18
670	94	0,95	89,30			4
680	90	0,94	84,60			1
690	80	0,94	75,20			

[a] Data for D_{55} daylight from CIE Publication 15.2 — 1986.

Table 2 — Relative spectral power distribution, S_λ, of ISO sensitometric studio tungsten illuminant

Wavelength, λ	Studio tungsten relative power	Relative spectral transmittance of the ISO standard lens	ISO sensitometric studio tungsten illuminant (studio tungsten transmitted by lens)	Weighted spectral sensitivities for calculating ISO/SDI of studio tungsten illuminant		
				Blue	Green	Red
nm	P_λ	$\overline{\tau}(\lambda)$	$S_\lambda = P_\lambda\ \overline{\tau}(\lambda)$	$W_B(\lambda)$	$W_G(\lambda)$	$W_R(\lambda)$
350	1	0,00	0	1		
360	3	0,07	0,21	2		
370	5	0,23	1,15	5		
380	8	0,42	3,36	12		
390	12	0,60	7,20	22		
400	16	0,74	11,84	32		
410	20	0,83	16,60	40		
420	24	0,88	21,12	44		
430	29	0,91	26,39	45		
440	34	0,94	31,96	40		
450	38	0,95	36,10	36		
460	43	0,97	41,71	31		
470	48	0,98	47,04	21	1	
480	53	0,98	51,94	11	1	
490	59	0,99	58,41	5	1	
500	64	0,99	63,36	2	2	
510	70	1,00	70,00	1	3	
520	76	1,00	76,00		5	
530	81	1,00	81,00		8	
540	88	1,00	88,00		15	
550	94	1,00	94,00		24	1
560	100	1,00	100,00		12	1
570	105	1,00	105,00		13	1
580	111	1,00	111,00		10	1
590	116	0,99	114,84		3	2
600	122	0,99	120,78		1	3
610	127	0,99	125,73			4
620	132	0,98	129,36			5
630	138	0,98	135,24			8
640	143	0,97	138,71			13
650	148	0,97	143,56			15
660	153	0,96	146,88			11
670	157	0,95	149,15			3
680	162	0,94	152,28			0
690	167	0,94	156,98			

Table 3 — Relative spectral power distribution, S_λ, of ISO sensitometric photoflood illuminant

Wavelength, λ	Photoflood relative power [a]	Relative spectral transmittance of the ISO standard lens	ISO sensitometric photoflood illuminant (photoflood transmitted by lens)	Weighted spectral sensitivities for calculating ISO/SDI of photoflood illuminant		
				Blue	Green	Red
nm	P_λ	$\bar{\tau}(\lambda)$	$S_\lambda = P_\lambda\ \bar{\tau}(\lambda)$	$W_B(\lambda)$	$W_G(\lambda)$	$W_R(\lambda)$
350	11	0,00				
360	14	0,07	0,98	2		
370	16	0,23	3,68	4		
380	19	0,42	7,98	9		
390	23	0,60	13,80	17		
400	26	0,74	19,24	25		
410	30	0,83	24,90	31		
420	34	0,88	29,92	34		
430	38	0,91	34,58	35		
440	42	0,94	39,48	31		
450	47	0,95	44,65	28		
460	52	0,97	50,44	24		
470	56	0,98	54,88	17	1	
480	61	0,98	59,78	9	1	
490	66	0,99	65,34	4	1	
500	71	0,99	70,29	1	2	
510	76	1,00	76,00	1	3	
520	81	1,00	81,00		5	
530	86	1,00	86,00		8	
540	91	1,00	91,00		15	
550	95	1,00	95,00		24	1
560	100	1,00	100,00		12	1
570	104	1,00	104,00		13	1
580	109	1,00	109,00		10	1
590	113	0,99	111,87		3	2
600	117	0,99	115,83		1	3
610	121	0,99	119,79			4
620	125	0,98	122,50			5
630	129	0,98	126,42			9
640	132	0,97	128,04			14
650	135	0,97	130,95			17
660	138	0,96	132,48			12
670	141	0,95	133,95			3
680	144	0,94	135,36			1
690	146	0,94	137,24			

[a] Calculated from Planck's equation using T = 3 400 K and $c_2 = 1{,}438\ 8 \times 10^{-2}$ m·K, the value recommended in CIE Publication 15.2 — 1986.

Table 4 — Relative spectral power distribution, S_λ, of ISO sensitometric printer illuminant

Wavelength, λ	Studio tungsten relative power [a]	Relative spectral transmittance of the ISO standard lens	Relative spectral transmittance of diffuser	ISO sensitometric printer illuminant (studio tungsten transmitted by lens and diffuser)	Weighted spectral sensitivities for calculating ISO/SDI of printer illuminant	
					Emulsion	**Dye**
nm	P_λ	$\bar{\tau}(\lambda)$	$\tau_d(\lambda)$	$S_\lambda = P_\lambda \bar{\tau}(\lambda)\, \tau_d(\lambda)$	$W_B(\lambda)$	$W_G(\lambda)$
350	1	0,00	0,00	0	90	
360	3	0,07	0,00	0	87	
370	5	0,23	0,00	0	83	
380	8	0,42	0,10	0,34	80	
390	12	0,60	0,43	3,10	79	
400	16	0,74	0,69	8,17	82	
410	20	0,83	0,78	12,95	97	
420	24	0,88	0,83	17,53	100	0,0
430	29	0,91	0,86	22,70	76	0,4
440	34	0,94	0,88	28,12	41	1,9
450	38	0,95	0,90	32,49	26	6,8
460	43	0,97	0,91	37,96	17	20,4
470	48	0,98	0,93	43,75	7	37,7
480	53	0,98	0,94	48,82	2	37,3
490	59	0,99	0,95	55,49	0	24,5
500	64	0,99	0,96	60,83		24,5
510	70	1,00	0,97	67,90		14,7
520	76	1,00	0,98	74,48		3,4
530	81	1,00	0,99	80,19		1,1
540	88	1,00	0,99	87,12		0,0
550	94	1,00	1,00	94,00		
560	100	1,00	1,00	100,00		

[a] Data for studio tungsten from Table 2.

Annex A
(informative)

Example sources

CAUTION — Manufacturers of selectively absorbing filters warn that a small variability in spectral properties is unavoidable. Therefore, it is necessary to have spectral transmittance data measured for the individual filter under consideration. Filters should be checked spectrophotometrically at regular intervals.

A.1 Introduction

Examples of actual lamp-filter combinations that meet the acceptance criterion are listed below. It is important to note that the standard illuminants are the spectral distributions, S_λ, given in Tables 1 to 4; the example illuminants given here are included as a convenience to users of this International Standard. These examples are not represented as the only combinations that meet the acceptable criteria, nor that they are necessarily the best of those available.

That there are specific filters shown in these examples should not be interpreted as a specification of these filters, nor that filters with spectral transmittances such as those listed are required. Any lamp-filter combination which meets the requirements of the normative parts of this International Standard is acceptable.

A.2 Daylight source

An incandescent tungsten or tungsten-halogen lamp operating at a distribution temperature of 2 856 K in conjunction with a Corning type 5900 glass filter or equivalent, of suitable thickness, mirror and glass on which a non-selective optical wedge (step or continuous) is mounted. Table A.1 illustrates how the spectral power distribution is determined, and shows how the SDI is calculated to determine whether it meets the specification for ISO sensitometric daylight.

A.3 Studio tungsten source

An incandescent tungsten or tungsten-halogen lamp operating at a distribution temperature of 2 856 K in combination with Corning type 5900 and Hoya L-39 glass filters (or equivalent) of appropriate thicknesses (preferably cemented together for strength) may be used.

A.4 Photoflood source

An incandescent tungsten or tungsten-halogen lamp operating at a distribution temperature of 2 856 K in conjunction with a Kodak Wratten gelatin filter No. 82C (or equivalent) may be used.

A.5 Printer source

An incandescent tungsten or tungsten-halogen lamp operating at a distribution temperature of 2 856 K in combination with a Schott GG395 glass filter (or equivalent) of appropriate thickness may be used. Table A.2 illustrates how the spectral power distribution is determined and shows how the SDI is calculated to determine whether it meets the specification for ISO sensitometric printer illuminant.

Table A.1 — Calculation of the ISO spectral distribution index for an example candidate sensitometric daylight illuminant

(Tungsten lamp at 2 856 K with Corning 5 900 glass, melt 2 829, 4,27 mm filter plus mirror and two pieces of clear glass)

Wave-length, λ	2 856 K relative power,	Mirror and glass trans-mittance	Corning 5900 trans-mittance	Candidate illuminant	Blue		Green		Red	
nm	P_λ	τ_1	τ_2	$S_\lambda = P_\lambda \tau_1 \tau_2$	$W_B(\lambda)$	$W_B(\lambda)S_\lambda$	$W_G(\lambda)$	$W_G(\lambda)S_\lambda$	$W_R(\lambda)$	$W_R(\lambda)S_\lambda$
360	6	0,73	0,14	0,6	1	0,6				
370	8	0,76	0,29	1,8	2	3,6				
380	10	0,78	0,43	3,4	5	17,0				
390	12	0,80	0,57	5,5	9	49,5				
400	15	0,82	0,67	8,2	14	114,8				
410	18	0,83	0,70	10,5	17	178,5				
420	21	0,84	0,64	11,3	19	214,7				
430	25	0,84	0,62	13,0	19	247,0				
440	29	0,84	0,57	13,9	17	236,3				
450	33	0,85	0,51	14,3	15	214,5				
460	38	0,86	0,46	15,0	13	195,0				
470	43	0,86	0,41	15,2	9	136,8	1	15,2		
480	48	0,87	0,37	15,5	5	77,5	1	15,5		
490	54	0,87	0,34	16,0	2	32,0	1	16,0		
500	60	0,88	0,31	16,4	1	16,4	2	32,8		
510	66	0,88	0,28	16,3	1	16,3	3	48,9		
520	72	0,88	0,26	16,5			5	82,5		
530	79	0,88	0,23	16,0			8	128,0		
540	86	0,88	0,21	15,9			15	238,5		
550	93	0,88	0,21	17,2			24	412,8	1	17,2
560	100	0,88	0,21	18,5			12	222,0	1	18,5
570	107	0,88	0,18	16,9			13	219,7	1	16,9
580	114	0,88	0,15	15,0			10	150,0	2	30,0
590	122	0,88	0,14	15,0			3	45,0	3	45,0
600	129	0,88	0,14	15,9			1	15,9	5	79,5
610	136	0,88	0,13	15,6					7	109,2
620	144	0,88	0,11	13,9					9	125,1
630	151	0,88	0,10	13,3					14	186,2
640	158	0,88	0,09	12,5					21	262,5
650	165	0,88	0,09	13,1					26	340,6
660	172	0,88	0,10	15,1					18	271,8
670	179	0,88	0,10	15,8					4	63,2
680	185	0,88	0,11	17,9					1	17,9
690	192	0,88	0,10	16,9						
Total photographic responses [$R = \Sigma\ W(\lambda)S_\lambda$]						1 750,5		1 642,8		1 583,6
$\log_{10}$ responses ($\log_{10} R$)						3,24		3,22		3,20
Subtract 3,20 (smallest value)						0,04		0,02		0,00
Multiply by 100						4		2		0
The ISO/SDI is 4/2/0 [a]										

[a] Rewriting the SDI making the green component equal to zero becomes 2/0/–2. It is obvious that this illuminant is within the tolerances specified in this International Standard.

Table A.2 — Calculation of the ISO spectral distribution index for an example candidate sensitometric printer illuminant

(Tungsten lamp at 2 856 K with Schott GG 395 glass filter)

Wavelength, λ	2 856 K relative power (Illuminant A)	Schott GG 395 transmittance	Candidate illuminant	Emulsion (blue)		Dye (blue-green)	
nm	P_λ	τ_λ	$S_\lambda = P_\lambda \tau_\lambda$	$W_B(\lambda)$	$W_B(\lambda)S_\lambda$	$W_G(\lambda)$	$W_G(\lambda)S_\lambda$
350	5	0,00	0	90			
360	6	0,00	0	87	0,0		
370	8	0,03	0,2	83	16,6		
380	10	0,15	1,5	80	120,0		
390	12	0,33	4,0	79	316,0		
400	15	0,50	7,5	82	615,0		
410	18	0,64	11,5	97	1 115,5		
420	21	0,73	15,3	100	1 530,0	0,0	0,0
430	25	0,79	19,8	76	1 504,8	0,4	7,9
440	29	0,82	23,8	41	975,8	1,9	45,2
450	33	0,84	27,7	26	720,2	6,8	188,4
460	38	0,85	32,3	17	549,1	20,4	658,9
470	43	0,86	37,0	7	259,0	37,7	1 394,9
480	48	0,87	41,8	2	83,6	37,3	1 559,1
490	54	0,87	47,0	0	0,0	24,5	1 151,5
500	60	0,88	52,8			24,5	1 293,6
510	66	0,88	58,1			14,7	854,1
520	72	0,88	63,4			3,4	215,6
530	79	0,88	69,5			1,1	76,5
540	86	0,88	75,7			0,0	0,0
550	93	0,88	81,8				
560	100	0,89	89,0				
Total photographic responses [$R = \Sigma\, W(\lambda)S_\lambda$]					7 805,6		7 445,7
$\log_{10}$ responses ($\log_{10}R$)					3,89		3,87
Subtract 3,89 (emulsion value)					0,00		– 0,02
Multiply by 100					0		– 2
The ISO/SDI is 0/–2 [a]							

[a] This illuminant is thus within the tolerances specified in this International Standard.

Annex B
(informative)

Exposure calculations

For the calibration of sensitometers, there are two basic expressions: radiometric and photometric. In the cases of sensitometry of camera films used in pictorial photography and black-and-white enlarging papers, the exposure is normally calculated in photometric units (lux seconds). The exposing source without any filtration produces a spectral irradiance, $E_{e\lambda}$, at the exposure plane. The total irradiance, expressed in watts per square metre, is then given by the integral

$$\int_0^\infty E_{e\lambda}\, d\lambda$$

Various elements, such as the lamp envelope, conversion filter and optical wedge, are generally located between the source of radiation and the exposure plane. If the total spectral transmittance of all these elements is $\tau(\lambda)$, the total irradiance is given by the equation

$$E_e = \int_0^\infty E_{e\lambda}\, \tau(\lambda)\, d\lambda$$

Multiplying the above value by exposure time yields the radiometric exposure value, $E_e t$, expressed in joules per square metre. The illuminance at the exposing plane, E_v in lux, is given by the equation

$$E_v = K_{max} \int_0^\infty E_{e\lambda}\, \tau(\lambda)\, V(\lambda)\, d\lambda$$

where

K_{max} is the maximum spectral luminous efficacy of radiant flux (683 lm/W);

$V(\lambda)$ is the spectral luminous efficiency for photopic vision.

The photometric exposure, $E_v t$, expressed in lux seconds for an exposure time, t, is then given by the equation

$$E_v t = 638t \int_{\lambda_1}^{\lambda_2} E_{e\lambda}\, \tau(\lambda)\, V(\lambda)\, d\lambda$$

where λ_1 to λ_2 is the wavelength range of the spectral luminous efficiency (approximately 390 nm to 760 nm).

Annex C
(informative)

Average colour film sensitivities

Table C.1 gives the average colour film relative spectral sensitivities for each film layer from which the weighting factors in Tables 1 to 3 were derived. The data are the average of the films produced by several manufacturers worldwide. Spectral sensitivity is the reciprocal of the energy required to produce a specified film density. The data were compiled in 1978 and are also used in ISO 3028 and ISO 6728.

Table C.1 — Average colour film relative spectral sensitivity, $\overline{s}(\lambda)$

(Sensitivity of each layer normalized to a peak of 100)

Wavelength, λ	Blue	Green	Red
nm	$\overline{s}_B(\lambda)$	$\overline{s}_G(\lambda)$	$\overline{s}_R(\lambda)$
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

Annex D
(informative)

Average black-and-white printing paper sensitivities

Table D.1 gives the average black-and-white paper relative spectral sensitivities for emulsion and sensitizing dye, from which the weighting factors in Table 4 were derived. The data are the average of papers produced by several manufacturers worldwide.

Table D.1 — Average black-and-white paper relative spectral sensitivity, $\overline{s}(\lambda)$

(Each sensitivity normalized to a peak of 100)

Wavelength, λ nm	**Emulsion** (blue) $\overline{s_{\mathrm{B}}}(\lambda)$	**Dye** (blue-green) $\overline{s_{\mathrm{G}}}(\lambda)$
350	90	
360	87	
370	83	
380	80	
390	79	
400	82	
410	97	
420	100	0
430	76	1
440	41	5
450	26	18
460	17	54
470	7	100
480	2	99
490	0	65
500		65
510		39
520		9
530		3
540		0
550		
560		

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