INTERNATIONAL STANDARD ISO 2239

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Photography – Light sources for use in sensitometric exposure – Simulation of the spectral distribution of daylight

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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.

International Standard ISO 2239 was drawn up by Technical Committee ISO/TC 42, *Photography*.

It was approved in September 1971 by the Member Bodies of the following countries :

Belgium	Japan	Thailand
Czechoslovakia	New Zealand	United Kingdom
Egypt, Arab Rep. of	Romania	U.S.A.
France	South Africa, Rep. of	U.S.S.R.
Germany	Spain	
Italy	Switzerland	

No Member Body expressed disapproval of the document.

Photography — Light sources for use in sensitometric exposure — Simulation of the spectral distribution of daylight

0 INTRODUCTION

The spectral quality of a sensitometric illuminant must closely match that of the radiant energy normally used in actual photography. In photography this quality is modified by the camera lens. The problem in specifying a suitable simulated daylight source is one of deciding just what spectral energy distribution best represents natural daylight, which varies with time, location, atmospheric conditions, and with orientation of the illuminated surface, and also of deciding what spectral transmittance best characterizes a representative photographic lens.

In this International Standard a light source for simulating daylight in sensitometric exposure is considered acceptable if the spectral energy distribution is the same, within specified limits, as that of natural daylight having a correlated colour temperature of 5 500 K and modified by the transmittance of a representative lens. On the basis of recently published data[1], it ~~apears~~ that this phase of daylight best represents conditions which are typical for photography, i.e., the sun is unobscured by clouds and at an altitude of 40°, the plane of the illuminated surface is nearly vertical and facing the sun in azimuth, and the atmosphere is relatively clear. The spectral energy distribution of daylight at a correlated colour temperature of 5 500 K has been reported by Judd, MacAdam and Wyszecki[2] and it is their data, modified by the transmittance of a representative lens, that provide the basis for the specification of standard sensitometric daylight in this International Standard. The spectral transmittance of a representative lens is subject to further study, but for the purposes of this International Standard the values given in Table 3 are considered reasonable and have been used in computing the spectral energy distribution of standard sensitometric daylight.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies requirements for light sources appropriate for use in the sensitometric exposure of photographic materials, both monochrome and colour. The spectral quality of the exposing radiant energy closely matches the spectral energy distribution of average daylight modified by the spectral transmittance of a representative camera lens (see Table 3), exclusive of the infrared.

1) H. R. Condit and F. Grum, J. Opt. Soc. Am. **54**, 1937 (1964)

2) D. B. Judd, D. L. MacAdam, G. Wyszecki, J. Opt. Soc. Am. **54**, 1931 (1964)

2 LIGHT SOURCE

2.1 General requirements

The light source shall be a lamp operated at a condition such that, with an absorbing filter if necessary, the energy incident on the exposure plane of the sensitometer will have, within the limits shown in Table 1, the spectral distribution shown for standard sensitometric daylight (SSD) (see Table 2).

2.2 Specific requirements

An illuminant meeting the requirements of this International Standard shall provide in each spectral interval the same portion of its total energy as is provided in the corresponding spectral interval by standard sensitometric daylight (SSD) (within the limits shown in Table 1).

An example of a suitable illuminant is given in the Annex.

TABLE 1 – **Requirements for relative spectral energy distribution**

Spectral interval	Relative energy of SSD	Energy/Total energy		
		SSD	Illuminant	
nm			Lower limits	Upper limits
360 to 400	115,0	0,040	0,035	0,045
410 to 450	362,0	0,127	0,122	0,132
460 to 500	494,6	0,173	0,168	0,178
510 to 550	510,1	0,178	0,173	0,183
560 to 600	480,8	0,168	0,163	0,173
610 to 650	460,9	0,161	0,156	0,166
660 to 700	436,9	0,153	0,148	0,158
Total	2 860,3	1,000		

The calculations of energy/total energy for each spectral interval of standard sensitometric daylight are indicated in Table 2.

TABLE 2 – **Relative spectral energy distribution of standard sensitometric daylight (5 500 K daylight and representative lens)**

Wavelength nm	Relative energy	Interval sum	Energy/Total energy
360	6,1		
370	14,1		
380	18,9		
390	27,1		
400	48,8	115,0	115/2 860 = 0,040
410	59,0		
420	64,4		
430	63,1		
440	81,3		
450	94,2	362,0	362/2 860 = 0,127
460	97,4		
470	97,9		
480	101,6		
490	97,0		
500	100,7	494,6	495/2 860 = 0,173
510	100,8		
520	100,0		
530	104,2		
540	102,1		
550	103,0	510,1	510/2 860 = 0,178
560	100,0		
570	97,3		
580	97,7		
590	91,4		
600	94,4	480,8	481/2 860 = 0,168
610	95,1		
620	94,2		
630	90,4		
640	92,3		
650	88,9	460,9	461/2 860 = 0,161
660	90,3		
670	94,0		
680	90,0		
690	79,7		
700	82,9	436,9	437/2 860 = 0,153
Total	2 860,3	Total	1,000

TABLE 3 – **Spectral transmittance of representative camera lens and of liquid filter**

Wavelength	Spectral transmittance	
nm	Camera lens	Liquid filter
360	0,20	0,404
370	0,41	0,500
380	0,58	0,591
390	0,71	0,671
400	0,80	0,728
410	0,86	0,768
420	0,90	0,788
430	0,93	0,783
440	0,95	0,755
450	0,96	0,707
460	0,97	0,654
470	0,98	0,609
480	0,99	0,567
490	0,99	0,519
500	1,00	0,463
510	1,00	0,407
520	1,00	0,364
530	1,00	0,337
540	1,00	0,317
550	1,00	0,297
560	1,00	0,274
570	1,00	0,250
580	1,00	0,228
590	1,00	0,209
600	1,00	0,194
610	1,00	0,183
620	1,00	0,174
630	1,00	0,166
640	1,00	0,158
650	1,00	0,152
660	1,00	0,145
670	1,00	0,136
680	1,00	1,127
690	1,00	0,118
700	1,00	0,108

ANNEX

EXAMPLE OF A SUITABLE ILLUMINANT

A.1 LIGHT SOURCE

Although other light sources and filters may be used, one light source which meets the specific requirements of 2.2 consists of an incandescent tungsten filament lamp operated at a colour temperature of 2 850 K together with a selectively absorbing filter[1)] having spectral transmittance values which conform to those in Table 3 and made up as described in section A.2.

A.2 FILTER

Two solutions shall be compounded according to the following formulae, the complete filter consisting of a 1 ± 0,005 cm layer of each solution contained in a double cell made by using three pieces of borosilicate crown glass (refractive index, n = 1,51) each 2,5 ± 0,05 mm thick. The working temperature of the filter shall be 20 ± 5 °C.

Solution A

Copper(II) sulphate ($CuSO_4.5H_2O$)	2,445	g
Mannitol [$C_6H_8(OH)_6$]	2,445	g
Pyridine (C_5H_5N)	30,0	ml
Water (distilled) to make	1 000,0	ml

Solution B

Ammonium cobalt(II) sulphate hexahydrate [$(NH_4)_2SO_4.CoSO_4.6H_2O$]	16,520	g
Copper (II) sulphate ($CuSO_4.5H_2O$)	19,020	g
Sulphuric acid (ρ = 1,84 g/ml)	10,0	ml
Water (distilled) to make	1 000,0	ml

The luminous transmittance of this filter to 2 850 K radiation is 0,262.

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1) Detailed consideration of the make-up of colour-correcting filters is given in NBS Miscellaneous Publication No. 114, duplicate copies of which may be purchased upon application from Photoduplication Section, Library of Congress, Washington, D.C. 20540, U.S.A.