INTERNATIONAL STANDARD ISO 3028

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Photography — Expendable photoflash lamps — Determination of relative spectral energy distribution for calculation of spectral distribution index

Photographie — Lampes à éclair à combustion — Détermination de la distribution spectrale énergétique relative en vue du calcul de l'indice de distribution spectrale

First edition — 1974-12-01

UDC 771.448.4 : 535.24 **Ref. No. ISO 3028-1974 (E)**

Descriptors : photography, photographic equipment, flash lamps, tests, optical tests, spectrum analysis, spectral distribution.

Price based on 6 pages

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 3028 was drawn up by Technical Committee ISO/TC 42, *Photography*, and circulated to the Member Bodies in March 1973.

It has been approved by the Member Bodies of the following countries :

Belgium	Japan	South Africa, Rep. of
Canada	Mexico	Spain
Czechoslovakia	Netherlands	Thailand
France	New Zealand	United Kingdom
Germany	Poland	U.S.S.R.
Italy	Romania	

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

U.S.A.

Printed in Switzerland

Photography — Expendable photoflash lamps — Determination of relative spectral energy distribution for calculation of spectral distribution index

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method which allows the determination of the characteristics of expendable photoflash lamps with respect to the relative spectral energy distribution, with the aim of calculating the Spectral Distribution Index (S.D.I.).

The testing method specified is applicable to expendable photoflash lamps in which the light is produced by combustion within a transparent envelope. The envelope can bear a transparent coating which adapts the spectral energy distribution to the spectral film sensitivity.

2 TEST METHOD

Since at least three different methods of measurement can be used, only those features of the test equipment are described which are necessary to obtain results of sufficient accuracy (see also annex B). The following method is recommended but should not be taken as mandatory. Alternative methods producing similar results may be used.

2.1 Electrical ignition of lamps (where applicable)

A direct-current supply source of 3 ± 0,1 V should be applied with such internal resistance that a current of 3,0 A can be obtained.

2.2 Photometric integrator

The lamp is mounted within a photometric integrator, for instance a sphere of at least 500 mm diameter, which has two measuring windows, one for the measurement of quantity of light, the other for the measurement of the spectral distribution.

2.3 Measurement of the quantity of light

The quantity of light is measured according to ISO 1229, *Photography — Expendable photoflash lamps — Determination of the light output.* All lamps having a quantity of light (lumen seconds) which differs more than 30 % from the nominal value are discarded from the measurements.

2.4 Spectral measurement

There are at least three different adequate measuring methods :

- with a monochromator;
- with a number of filters and corresponding receivers;
- with a spectrograph.

All of them can give satisfactory results. The final measurement results are given for 17 spectral ranges of which the central wavelength lies at 360, 380, 400, . . . , 660, 680 nm. The effective bandwidth shall be 10 to 20 nm. Within each wavelength range ten lamps are measured. The ratio of the spectral measurement and the quantity of light is obtained for each lamp separately. From these ten ratios the mean value for that spectral range is obtained.

2.5 Time response and time integration

The receivers in combination with their electric circuits shall have a response time of not more than 0,1 ms. The total and the spectral light flux are integrated over the entire duration of the flash.

2.6 Repeatability

The spectral and the total measurement shall reproduce within ± 1 %.

3 CALIBRATION

The light source used for calibration shall approximate as much as possible to the spectral and time characteristics of the flash lamp; for example a xenon-flash unit, consisting of a xenon-flash lamp in combination with an ignition device with a correspondingly chosen current density and decay time. If a xenon-flash is used, it should be calibrated by a national laboratory or another equivalent independent institute; a stable capacitor and closely controlled voltage shall be used.

4 NORMALIZATION AND TABULATION

For normalization, the 17 spectral values are divided by the one at 500 nm. The resulting relative spectral energy distribution is plotted and tabulated as shown in annex C.

5 DETERMINATION OF SPECTRAL DISTRIBUTION INDEX

Spectral Distribution Index is a three-number designation describing the spectral emission characteristics of a light source in terms of the relative photographic responses (P_b, P_g and P_r) of the three component emulsions. By expressing the photographic responses in logarithmic form and making one of the elements of this three-part number equal to zero by subtracting the smallest number from all three parts, the designation is simplified. A further simplification is achieved if the logarithms are expressed to two decimal places and the decimal is then eliminated by multiplying by 100.

The determination of S.D.I. requires the computation of P_b, P_g and P_r in accordance with the following equations :

$$P_b = \int_0^\infty Q_\lambda \, W_\lambda \, (B) \, d\lambda$$

$$P_g = \int_0^\infty Q_\lambda \, W_\lambda \, (G) \, d\lambda$$

$$P_r = \int_0^\infty Q_\lambda \, W_\lambda \, (F) \, d\lambda$$

where

Q_λ is the relative energy of the light source at wavelength λ;

W_λ (B) is the weighted effective sensitivity of the blue component emulsion;

W_λ (G) is the weighted effective sensitivity of the green component emulsion;

W_λ (R) is the weighted effective sensitivity of the red component emulsion.

For the purpose of this International Standard, the integrations may be replaced by finite sums of terms.

It is normal practice for the film used to be balanced for 5 500 K and therefore the S.D.I. should be 0 – 0 – 0. For this condition the calculations are based on the spectral energy distribution of natural daylight having a correlated colour temperature of 5 500 K (see table 1 and annex A). In table 2 the values of W_λ (B), W_λ (G) and W_λ (R) are given which represent the weighted spectral sensitivities of the three component emulsions.

Table 3 illustrates the method of calculating the S.D.I. for 5 500 K daylight, for which the values of Q_λ are taken from table 1.

Summary : S.D.I. is determined as follows : Calculate P_b, P_g and P_r (the photographic responses of the blue, green and red emulsions respectively) as indicated above. Obtain, to two decimal places, $\log_{10}P_b$, $\log_{10}P_g$, $\log_{10}P_r$. Multiply each by 100 to eliminate the decimal, and subtract X (the smallest of these three quantities) so that one quantity of this three-part number equals zero.

$$\text{S.D.I.} = 100 \log_{10}P_b - X \quad - \quad 100 \log_{10}P_g - X \quad - \quad 100 \log_{10}P_r - X$$

TABLE 1 – **Spectral energy distribution of 5 500 K daylight**

λ	Q_λ
360	30,7
380	32,6
400	61,0
420	71,6
440	85,6
460	100,4
480	102,6
500	100,7
520	100,0
540	102,1
560	100,0
580	97,7
600	94,4
620	94,2
640	92,3
660	90,3
680	90,0

TABLE 2 – **Weighted spectral sensitivities of an average daylight colour film corrected for lens transmittance**

λ	W_λ (B)	λ	W_λ (G)	λ	W_λ (R)
360	3	480	2	560	1
380	12	500	6	580	3
400	20	520	13	600	5
420	22	540	19	620	13
440	19	560	18	640	27
460	13	580	9	660	23
480	6	600	1	680	2

TABLE 3 – **Calculation of the spectral distribution index of 5 500 K daylight**

λ	Q_λ	W_λ (B)	$Q_\lambda W_\lambda$ (B)	W_λ (G)	$Q_\lambda W_\lambda$ (G)	W_λ (R)	$Q_\lambda W_\lambda$ (R)
360	30,7	3	92				
380	32,6	12	391				
400	61,0	20	1 220				
420	71,6	22	1 575				
440	85,6	19	1 626				
460	100,4	13	1 305				
480	102,6	6	616	2	205		
500	100,7			6	604		
520	100			13	1 300		
540	102,1			19	1 940		
560	100			18	1 800	1	100
580	97,7			9	879	3	293
600	94,4			1	94	5	472
620	94,2					13	1 225
640	92,3					27	2 492
660	90,3					23	2 077
680	90,0					2	180
		P_b =	6 825	P_g =	6 822	P_r =	6 839
		$\log_{10} P_b$ =	3,83	$\log_{10} P_g$ =	3,83	$\log_{10} P_r$ =	3,83
		Multiplying by 100 =	383		383		383
		Subtracting 383 =	0		0		0

Spectral distribution index = 0 – 0 – 0

ANNEX A

COLOUR TEMPERATURE

The use of the colour temperature for characterization of the spectral energy distribution has some disadvantages.

First, it has no direct correspondence to the film sensitivity. Second, the wavelength range where the x-function is active has relatively too heavy a weight with respect to the colour temperature (1 % change in x corresponds to approximately 130 K in T_c at 5 500 K). However, since it is now so widely in use and, furthermore, since there is no generally accepted film sensitivity with corresponding S.D.I., it will nevertheless be used together with the S.D.I. Therefore, the following table gives the CIE spectral tristimulus values $\overline{x}(\lambda)$, $\overline{y}(\lambda)$ and $\overline{z}(\lambda)$.

TABLE 4

Wavelength	CIE spectral tristimulus values[1]		
	$\overline{x}(\lambda)$	$\overline{y}(\lambda)$	$\overline{z}(\lambda)$
360			
380			
.			
.			
.			
680			

ANNEX B

GENERAL REMARKS ON THE TEST EQUIPMENT

B.1 The best form for the photometric integrator is the sphere. A cube with cut-off corners can also be used.

B.2 The paint of the photometric integrator shall not discolour too quickly. The reflectivity of the paint shall be checked regularly by calibration.

B.3 The resolution of the spectral apparatus shall not be too high, otherwise irregularity in the spectral distribution may cause differences in the result or the bandwidth of 10 to 20 nm cannot be realized.

B.4 If lenses or mirrors are used in or outside the spectral apparatus, they shall be fully illuminated.

B.5 When wavelength calibration is performed, the bandwidth must be 10 times smaller than used for the measurements (1 to 2 nm), without changing the band-width-centre.

B.6 When integrating the receiver signal over the duration of the flash, the dark current has to be compensated.

B.7 Shifting or replacing of the receiver may make a new calibration necessary.

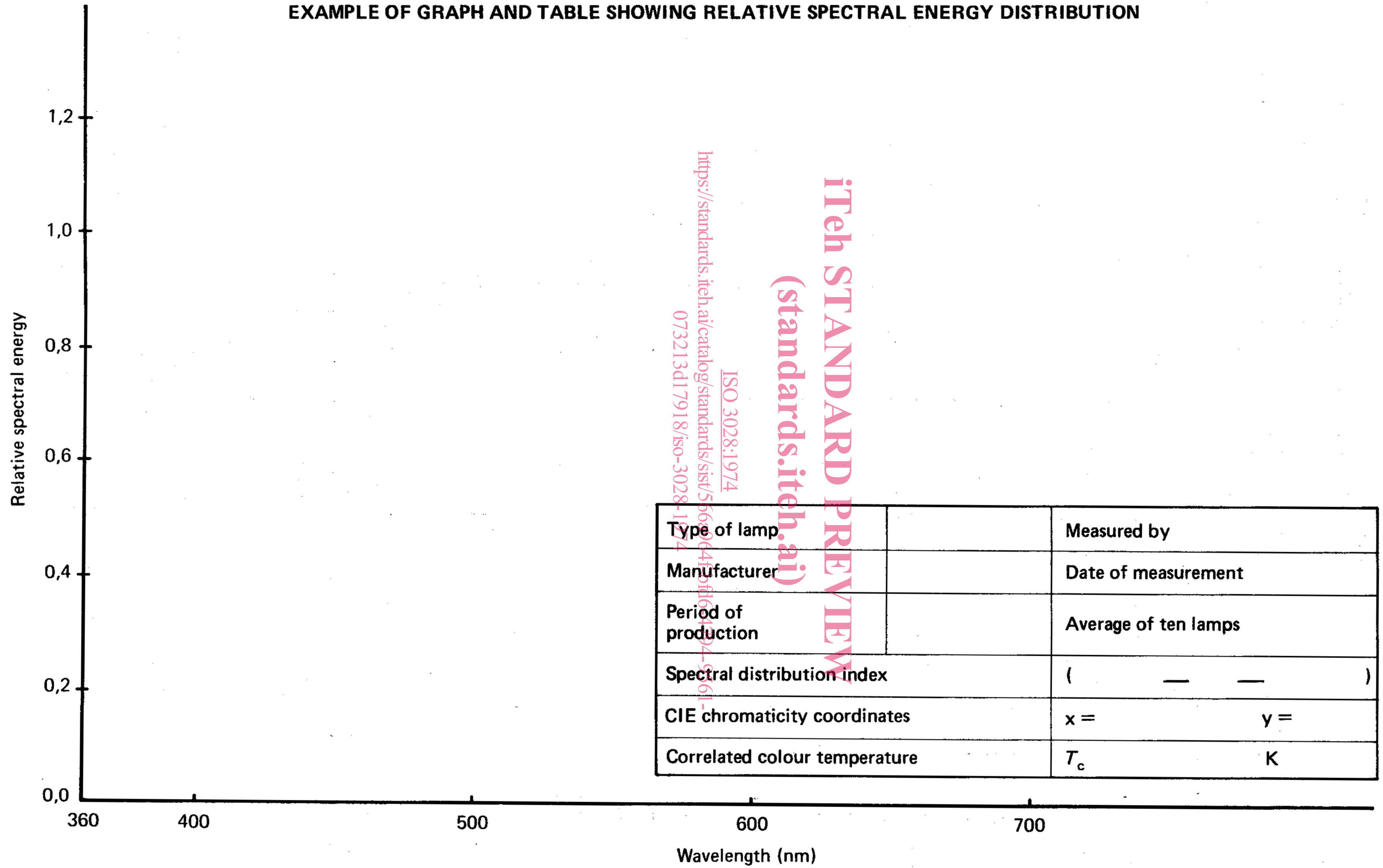
B.8 The necessary accuracy for these measurements is greater than in many other cases of light measurements. A systematic error of 1 % in the relevant spectral range gives an error of 130 K in T_c, i.e. 0,5 in one of the spectral distribution indexes.

B.9 Care should be taken to minimize capacitance effects in leads connecting high impedance parts of the equipment.

1) Values given in CIE Publication No. 15 [E-1.3.1 (1971)], *Colorimetry*, Paris, CIE Bureau Central, 1971.

ANNEX C

EXAMPLE OF GRAPH AND TABLE SHOWING RELATIVE SPECTRAL ENERGY DISTRIBUTION



Type of lamp		Measured by
Manufacturer		Date of measurement
Period of production		Average of ten lamps
Spectral distribution index		(— —)
CIE chromaticity coordinates		x = y =
Correlated colour temperature		T_c K

FIGURE 1 — Typical graph of relative spectral energy distribution

Spectral energy distribution of photoflash lamps

Type of lamp	Measured by	Date of measurement

		Manufacturer						
	λ	a	b	c	d	e	f	g
Relative spectral energy	360							
	380							
	400							
	420							
	440							
	460							
	480							
	500	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	520							
	540							
	560							
	580							
	600							
	620							
	640							
	660							
	680							
Spectral distribution index		2,5 0 4,5						
Chromaticity coordinates	x = y =	0,350 0,380						
Correlated colour temperature		5 000						

FIGURE 2 — Typical table of relative spectral energy distribution