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Photography — Colour reversal camera films — Determination of ISO speed

*Photographie — Films de prise de vue inversibles en couleur —
Détermination de la sensibilité ISO*



Reference number
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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 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2240 was prepared by Technical Committee ISO/TC 42, *Photography*.

This fourth edition cancels and replaces the third edition (ISO 2240:1994), which has been technically revised.

Introduction

The ISO speeds are intended to provide correct exposures with exposure meters conforming to ISO 2720, and, where applicable, automatic exposure controls for cameras conforming to ISO 2721; the resultant camera exposure will normally lead to colour transparencies or motion pictures of the best quality. For an average scene and average camera, the indicated camera exposure will be approximately midway between the least exposure and the greatest exposure required to produce transparencies and motion-picture films suitable for viewing at normal luminance levels.

For the purpose of this International Standard, the normal luminance of transparency illuminators is assumed to be that described in ISO 3664 with a ratio of direct-to-ambient luminance of about 40:1. The normal luminance of transparency projection screens is assumed to be about 137 cd/m².

Screen luminance of 8 mm Type R and 8 mm Type S (Super-8) motion-picture film projection is assumed to range from approximately 40 cd/m² (see ISO 2910) to 62 cd/m². Therefore, it may be desirable to increase exposure by 25 % above that obtained by using the speed derived by following the sensitometric procedure described in this International Standard. Many camera manufacturers design and calibrate their 8 mm Type R and 8 mm Type S motion-picture cameras with an adjustment which permits more exposure to compensate for the lower screen luminance of the usual projection conditions (see ISO 2721).

Photography — Colour reversal camera films — Determination of ISO speed

1 Scope

This International Standard specifies the method for determining the ISO speed of colour reversal camera films producing continuous-tone pictorial images that are intended to be viewed on transparency illuminators or by projection as slides. It also applies to 8 mm and 16 mm motion-picture films used in non-professional applications.

This International Standard is not applicable to professional motion-picture films regardless of their applications.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5-2, *Photography — Density measurements — Part 2: Geometric conditions for transmission density*

ISO 5-3, *Photography — Density measurements — Part 3: Spectral conditions*

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

3 Terms and definitions

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

3.1

exposure

H

time integral of illuminance on the film

NOTE 1 In the *International lighting vocabulary*^[8], H is defined as the luminous exposure. In this International Standard, "luminous exposure" is simply referred to as "exposure".

NOTE 2 Exposure is measured in lux seconds.

NOTE 3 Exposure is often expressed in $\log_{10}H$ units.

3.2

speed

quantitative measure of the response of the photographic material to radiant energy for the specified conditions of exposure, processing, density measurement and analysis

3.3

minimum density

minimum density value obtainable following the process used in the ISO speed determination

4 Sampling and storage

In determining the ISO speed of a product, it is important that the samples evaluated yield the average results obtained by users. This requires evaluating several different batches periodically under the conditions specified in this International Standard. Prior to evaluation, the samples shall be stored according to the manufacturers' recommendations for a length of time to simulate the average age at which the product is normally used. To assure that all components of variance are included in the sampling plan, it is recommended that procedures such as those outlined in ISO Standards Handbook^[7] be used. The objective in selecting and storing samples as described above is to ensure the film characteristics are representative of those obtained by a photographer at the time of use.

5 Test method

5.1 Principle

Samples are exposed and processed in the manner specified below. Density measurements are obtained from the resultant images to produce a sensitometric curve from which values are taken and used to determine ISO speed.

5.2 Safelights

To eliminate the possibility of safelight illumination affecting the sensitometric results, all films shall be handled in complete darkness during sample preparation, exposing and processing.

5.3 Exposure

5.3.1 Sample conditions

During exposure, the samples shall be equilibrated with air at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %.

5.3.2 Type of sensitometer

The sensitometer shall be a non-intermittent, illuminance-scale type.

5.3.3 Radiant energy quality

The appropriate illuminant for the particular film type being exposed shall conform to the specification given in ISO 7589. ISO speed may be determined using ISO sensitometric daylight, studio tungsten, or photoflood illuminants. Since the speed of film process combinations depends on the type of illuminant used, the illuminant should be specified in the instructions.

ISO speed shall be specified for use without a filter in front of the camera lens. If a film is used with a colour filter in front of the camera lens, an "equivalent" speed number can be used to determine the exposure of the film with the filter. ISO speed is not applicable to the filtered condition.

5.3.4 Modulation

The total range of spectral diffuse transmission density with respect to the film plane of each area of the light modulator throughout the wavelength interval from 400 nm to 700 nm shall not exceed 5 % of the average

density obtained over the same interval or 0,03 density, whichever is greater. In the interval from 360 nm to 400 nm, 10 % of this same average density or 0,06 density, whichever is greater, is acceptable.

If stepped increment modulation is used, the exposure increment shall not be greater than $0,15 \log_{10} H$. The width and length of a single step shall be adequate to obtain a uniform density within the reading aperture specified for densitometry.

If a continuous variable modulator is used, the change in exposure with distance along the test strip shall be uniform and not greater than $0,04 \log_{10} H$ per millimetre.

5.3.5 Exposure time

The exposure time shall be between 5 s and 1/1 000 s corresponding to the usage practice for the particular film tested. Since the speed of film is dependent on exposure time because of reciprocity law failure, the exposure time used for determining ISO speed should be specified in use instructions.

5.4 Processing

5.4.1 Conditioning of samples

In the time interval between exposure and processing, the samples shall be equilibrated with air at $(23 \pm 2) ^\circ\text{C}$ and a relative humidity of $(50 \pm 5) \%$. The processing shall be completed in no fewer than 5 days and no more than 10 days after exposure for general-purpose films, and no fewer than 4 h and no more than 7 days for professional films.

5.4.2 Processing specifications

No processing specifications are described in this International Standard in recognition of the wide range of chemicals and equipment used. ISO speed provided by film manufacturers generally applies to the film when it is processed in accordance with their recommendations to produce the photographic characteristics specified for the process. Processing information shall be available from film manufacturers or others who quote ISO speed. This shall specify the chemicals, time, temperatures, agitation and procedure used for each of the processing steps and any additional information required to obtain the sensitometric results described.

The values for speed obtained using various processing procedures can differ significantly. Although different speeds for a particular film can be achieved by varying the process, the user should be aware that other sensitometric and physical changes can also accompany the speed changes.

5.5 Densitometry

ISO standard visual diffuse transmission density of the processed images shall be measured using a densitometer complying with the geometric conditions specified in ISO 5-2 and the spectral conditions specified in ISO 5-3. These conditions are designated:

$$D_T(90^\circ \text{opal}; S_H: \leq 10^\circ; V_T)$$

or

$$D_T(\leq 10^\circ; S_H: 90^\circ \text{opal}; V_T)$$

Readings shall be made in a uniform area of the image, typically at least 1 mm from the edges of the exposures.

5.6 Evaluation

5.6.1 Sensitometric curve

The ISO standard visual diffuse transmission density values are plotted against the logarithm to the base 10 of the corresponding exposures (H) expressed in lux seconds, to obtain a sensitometric curve similar to that illustrated in Figure 1.

5.6.2 Minimum density

The minimum density shall be determined from a film sample adequately exposed to produce the minimum density possible and processed simultaneously with the sample exposed for determining the sensitometric curve.

5.6.3 Determination of H_m and $\log_{10}H_m$

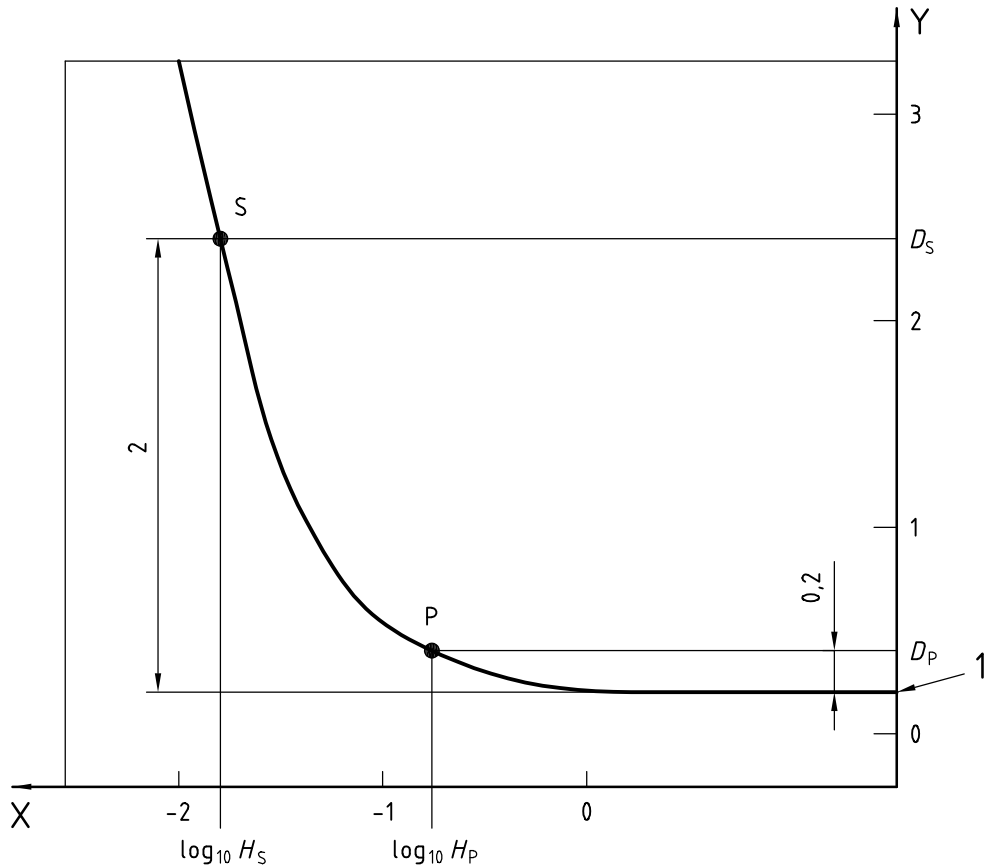
The method for determining ISO speed is illustrated in Figure 1. Point P is located on the sensitometric curve at the density of 0,20 above the minimum density. Point S is then located on the curve 2,00 above the minimum density to bracket the normal range of density in a typical transparency. In order to represent a reasonable reproduction of the scene, the slope of the line between points P and S should fall between $-1,4$ and $-1,8$. The exposures H_P and H_S correspond to points P and S, and are used to compute the exposure H_m by use of the following formulae:

$$\log_{10}H_m = \frac{\log_{10}H_S + \log_{10}H_P}{2} \quad (1)$$

or

$$H_m = \sqrt{H_S H_P} \quad (2)$$

The exposure, H_m , represents the exposure in lux seconds, used to determine the ISO speed.



Key

- X $\log_{10}H$ (H expressed in lux seconds)
- Y ISO standard visual diffuse transmission density
- 1 minimum density

Figure 1 — Sensitometric curve

6 Product classification

6.1 ISO speed

6.1.1 ISO speed scale

The speed scales given in Table 1 are derived from Equations (3) and (4):

$$S = \frac{10}{H_m} \tag{3}$$

$$S^{\circ} = 1 + 10 \log_{10} \left(\frac{10}{H_m} \right) \tag{4}$$

$$= 1 + 10 \log_{10} (S)$$

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where

S is the arithmetic speed;

S° is the logarithmic speed.

"ISO" speed shall be obtained directly from $\log_{10}H_m$ by use of Table 1 which shows the corresponding rounded values of S and S° .

6.1.2 ISO speed of a product

The ISO speed of a product (as distinguished from that of a specific sample) shall be based on the arithmetic mean of the logarithms of exposures, $\log_{10}H_m$ determined from several batches of the product when selected, stored and tested as specified above (see Clauses 4 and 5). The ISO speed of a product with proper rounding is then determined from the average value of $\log_{10}H_m$ by use of Table 1.

Since ISO speed is dependent on exposure and processing conditions, these should be indicated when quoting ISO speed values.

6.2 Accuracy

The calibration of the equipment and processes involved in determining film speed shall be adequate to ensure the absolute value of the error in $\log_{10}H_m$ is less than 0,05.

7 Product marking and labelling

The speed of a product determined by the method described in this International Standard and expressed on the scales of Table 1 may be designated ISO speed and denoted in the form of ISO 100, ISO 21° or ISO 100/21°.

Table 1 — ISO speed

Log ₁₀ H _m		ISO speed	
from	to	arithmetic	logarithmic
-2,55	-2,46	3 200	36°
-2,45	-2,36	2 500	35°
-2,35	-2,26	2 000	34°
-2,25	-2,16	1 600	33°
-2,15	-2,06	1 250	32°
-2,05	-1,96	1 000	31°
-1,95	-1,86	800	30°
-1,85	-1,76	640	29°
-1,75	-1,66	500	28°
-1,65	-1,56	400	27°
-1,55	-1,46	320	26°
-1,45	-1,36	250	25°
-1,35	-1,26	200	24°
-1,25	-1,16	160	23°
-1,15	-1,06	125	22°
-1,05	-0,96	100	21°
-0,95	-0,86	80	20°
-0,85	-0,76	64	19°
-0,75	-0,66	50	18°
-0,65	-0,56	40	17°
-0,55	-0,46	32	16°
-0,45	-0,36	25	15°
-0,35	-0,26	20	14°
-0,25	-0,16	16	13°
-0,15	-0,06	12	12°
-0,05	0,04	10	11°
0,05	0,14	8	10°
0,15	0,24	6	9°
0,25	0,34	5	8°
0,35	0,44	4	7°

Bibliography

- [1] ISO 5-1:1984, *Photography — Density measurements — Part 1: Terms, symbols and notations*
- [2] ISO 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*
- [3] ISO 2720:1974, *Photography — General purpose photographic exposure meters (photoelectric type) — Guide to product specification*
- [4] ISO 2721:1982, *Photography — Cameras — Automatic controls of exposure*
- [5] ISO 2910:1990, *Cinematography — Screen luminance for the projection of motion-picture prints in indoor theatres and review rooms*
- [6] ISO 3664:2000, *Viewing conditions — Graphic technology and photography*
- [7] ISO Standards Handbook (2 volumes), *Statistical methods for quality control*, 5th edition, 2000
- [8] CIE Publication No. 17.4 (1987), *International lighting vocabulary*, 4th edition

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