International Standard ISO 6846

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Photography — Black-and-white continuous-tone papers — Determination of ISO speed and range for printing

Photographie — Papiers noir et blanc pour images à tons continus — Détermination de la sensibilité ISO et de l'étendue ISO

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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 developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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 6846 was developed by Technical Committee ISO/TC 42, *Photography*, and was circulated to the member bodies in March 1982.

It has been approved by the member bodies of the following countries :

Australia	France	South Africa, Rep. of
Austria	Germany, F. R.	Spain
Belgium	Italy	United Kingdom
Canada	Japan	USA
China	Mexico	USSR
Czechoslovakia	Netherlands	
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No member body expressed disapproval of the document.

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Photography — Black-and-white continuous-tone papers — Determination of ISO speed and range for printing

0 Introduction

This International Standard establishes a method for measuring those photographic characteristics of papers used for printing from negative images which will aid users to select the appropriate products for their applications. ISO speed and ISO range are two measurements considered important for this purpose.

Studies[1] have shown that highly acceptable prints are generally obtained if the log exposure range (LER) of a photographic paper is equal to the effective density range of the negative. Therefore, ISO range, which is directly related to LER (i.e., ISO range = 100 LER) provides a useful criterion for grading papers. Some diversion from this criterion may be required to obtain optimum prints because of subject matter, individual preferences, and paper characteristics such as D_{max}, surface, and curve shape.

Each manufacturer has established his own unique system for grading of papers and designations which makes it extremely difficult for users to identify products which are comparable for printing characteristics. The ISO range numbers introduced to reduce this source of confusion. It is expected that manufacturers will adopt the ISO range to replace the multitude of grading systems currently in use.

ISO range is not a measure of image contrast, but a useful guide for selecting the proper paper for a given effective negative density range and for comparing products from various manufacturers. Image contrast is a function of the sensitometric characteristics of a paper and of the visual perception of the final image (see annex C). It is recognized that while ISO speed and ISO range are measurable parameters, they are useful only as guides, since photographic printing depends on the subject matter, the equipment used, and how the subject is interpreted by the photographer.

The diffuse density range of a negative is not an accurate measure of the illuminance range at the printing plane when printers are employed that have semi-diffuse or specular type optical systems. Since conditions which satisfy the diffuse density criteria normally exist only in contact printing, the term "effective density range" has been introduced.

It is the effective density range of the negative which should be matched with the log exposure range of the printing material in the usual projection printing mode for optimum tone reproduction.

The effective density range of a negative image can be calculated from the measured ISO diffuse transmission density range by applying the proper correction factors for specularity and flare to the values. Alternatively, the illuminance range can be measured in the printing plane with a suitable photometer (see annex A).

Most manufacturers have classified photographic papers by using a grade number ranging from 00 to 6. The larger the grade number, the greater is the emulsion contrast within a specific line of papers.

ISO range numbers will generally be lower as emulsion contrast increases. The concept of ISO range was adopted recognizing that users generally evaluate the density range of a negative (visually) in selecting the paper grade to use. If the density range is small, a paper with a small ISO range number should be used. It will take time to adapt to this new concept, but establishing an internationally accepted method of classifying papers in this manner will have significant long-term benefits for users.

It is not feasible to include provisions in this International Standard for the wide range of exposing conditions used in the trade. For this reason, the interpretation of the speed and range numbers obtained by following the procedures herein may not be directly applicable when products are exposed using sources other than a tungsten lamp operating at 3 000 K.

Since a particular paper is designed to provide optimum results in particular processes, this International Standard does not specify one single process. To do so would be considered unduly restrictive and could result in yielding ISO speed and range numbers which were not typical of those obtained in processes specified by the manufacturer.

1 Scope and field of application

This International Standard specifies the method for determining the ISO speed and range of black-and-white photographic papers used to make positive reflection prints of continuous-tone subjects from black-and-white film negatives. It pertains

1) Control of Photographic Printing : Improvements in Terminology and Further Analysis of Results; JONES, L.A. and NELSON, C.N., *Journal of the Optical Society of America*, Vol 38, **11** (Nov. 1948).

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to all conventional silver-halide contact and enlarging papers used for continuous-tone or pictorial photography. This includes papers with variable contrast. The papers may be processed in conventional chemicals and equipment, but also using special procedures such as those involving activators or heat for development.

This International Standard does not apply to

a) non-silver papers;

b) high contrast silver papers, such as those used in the graphic arts, or other non-pictorial applications;

c) silver papers used to obtain a direct positive or reversal image.

2 References

ISO 5, *Photography — Density measurements*

— *Part 1 : Terms, symbols and notations for reflection and transmission density.*[1)]

— *Part 2 : Geometrical conditions for transmission density.*[1)]

— *Part 3 : Spectral conditions.*[1)]

— *Part 4 : Geometrical conditions for reflection density.*[1)]

ISO 7589, *Photography — Sensitometric illuminants — Specifications for daylight and incandescent tungsten.*[2)]

3 Definitions

For the purpose of this International Standard, the following definitions apply :

3.1 exposure (H) : The time integral of illuminance on the paper measured in lux seconds and designated by the symbol H. Exposure is often expressed in $\log_{10}H$ units.

3.2 speed : A quantitative measure of the response of the photographic material to radiant energy for the specified conditions of exposure, processing, and image measurement.

3.3 log exposure range (LER) : The range of log exposure values normally used to produce a final print. It is the difference in log exposure values required to produce two specified densities on the paper.

4 Sampling and storage

In determining the ISO speed and ISO range of a product, it is important that the samples evaluated yield the average results obtained by users. This will require evaluating several different batches periodically under the conditions specified in this International Standard. Prior to evaluation, the samples shall be stored according to the manufacturer's recommendations for a length of time to simulate the average age at which the product is normally used. Several independent evaluations shall be made to ensure the proper calibration of equipment and processes. The basic objective in selecting and storing samples as described above is to ensure the paper characteristics are representative of those obtained by a consumer at the time of use.

5 Method of test

5.1 Principle

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

5.2 Safelights

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

5.3 Exposure

5.3.1 Sample condition

During exposure, the samples shall be at a temperature of 23 ± 2 °C and a relative humidity of 50 ± 2 %.

5.3.2 Type of sensitometer

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

5.3.3 Radiant energy quality

The spectral energy distribution of the light source shall be equivalent to that of a blackbody radiator at a colour temperature of 3 000 ± 50 K, modified by a typical lens as described in ISO 2239.

If this International Standard is followed in all respects except that the light from the source is modified by a filter, as in the case of variable contrast papers, this International Standard may be complied with by giving a clear indication that the speed and range quoted apply to the particular combination of paper and filter used.

5.3.4 Modulation

The total range of spectral diffuse transmission density with respect to the paper plane of each area of the light modulation throughout the wavelength interval from 400 to 700 nm shall not exceed 5 % of the average density, or 0,03 density, whichever is greater. In the interval from 360 to 400 nm, 10 % of this same average density or 0,06 density, whichever is greater, is acceptable.

1) At present at the stage of draft. (Revision of ISO 5-1974.)

2) At present at the stage of draft.

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If stepped increments are 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 area (devoid of adjacent effects) within the reading aperture specified for densitometry.

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

5.3.5 Exposure time

The exposure time shall be between 0,1 and 10 s corresponding with the usage practice for the particular paper tested. Since the speed of paper is dependent on exposure time because of reciprocity law failure effects, the exposure time used for determining the ISO and range should be specified in use instructions.

An area of the paper shall not be exposed to produce the minimum density possible.

5.4 Processing

5.4.1 Conditioning of samples

In the time interval between exposure and processing, the samples shall be kept at 23 ± 2 °C and a relative humidity of 50 ± 2 %. The processing shall be completed between 1 min and 2 h after exposure.

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 and range provided by paper

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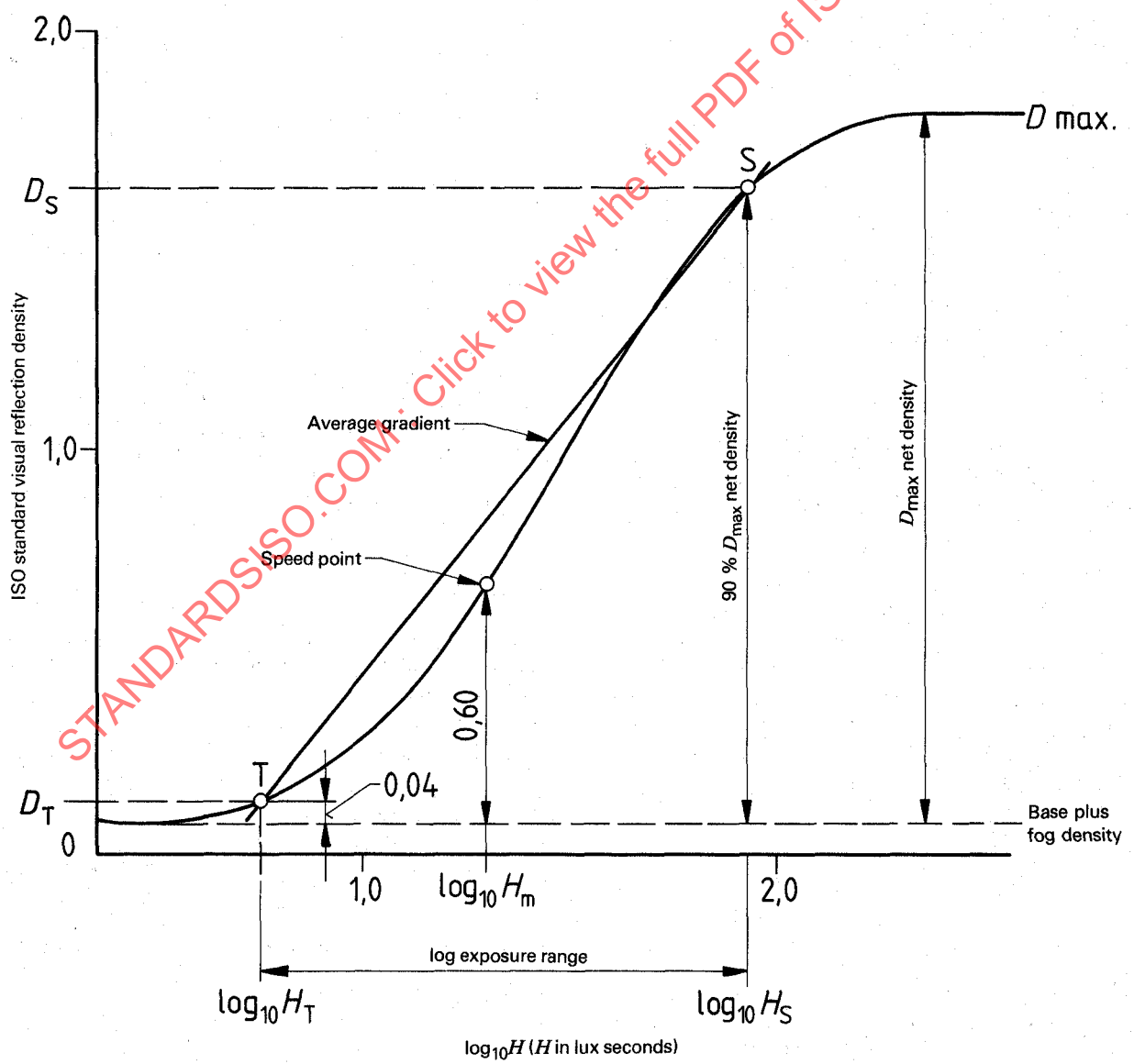

Figure — Sensitometric curve

manufacturers generally apply to the paper when it is processed in accordance with their recommendations to produce the photographic characteristics specified for the process. Process information shall be available from the paper manufacturers or others who quote ISO speed and range. This shall specify the chemicals, times, temperatures, agitation, equipment and procedure used for each of the processing steps, and any additional information required to obtain the sensitometric results described. The values for speed and range obtained using various processing procedures may differ significantly. Although different speeds or ranges for a particular paper may be achieved by varying the processes, the user should be aware that other sensitometric and physical changes may also accompany the speed and range changes.

5.5 Densitometry

The ISO standard visual reflection density of the processed paper images shall be measured using a densitometer complying with the geometric requirements specified in ISO 5/4 and the spectral requirements specified in ISO 5/3. A minimum reading aperture of 3,0 mm diameter shall be used. Readings shall be at least 1 mm from the edges of the exposures.

5.6 Evaluation

5.6.1 Sensitometric curve

The ISO standard visual reflection 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 the figure.

5.6.2 Base plus fog density

The combination of base plus fog density shall be determined from an unexposed sample of the same paper processed simultaneously with the sample exposed for determining the sensitometric curve.

6 Product classification

6.1 ISO speed

6.1.1 ISO speed scale

The speed scale given in table 1 is derived from the formula

$$S = \frac{1\,000}{H_m}$$

where

S is the speed;

H_m is the exposure, in lux seconds, required to produce a density of 0,60 above base plus fog density.

"ISO" speed shall be obtained directly from the $\log_{10} H_m$ by use of table 1 which shows the rounding method to be used.

Table 1 — ISO speed scale

$\log_{10} H_m$ from	$\log_{10} H_m$ to	ISO speed
−0,55	−0,46	P3 200
−0,45	−0,36	P2 500
−0,35	−0,26	P2 000
−0,25	−,026	P1 600
−0,15	−0,06	P1 250
−0,05	0,04	P1 000
0,05	0,14	P800
0,15	0,24	P640
0,25	0,34	P500
0,35	0,44	P400
0,45	0,64	P320
0,55	0,64	P250
0,65	0,74	P200
0,75	0,84	P160
0,85	0,94	P125
0,95	1,04	P100
1,05	1,14	P80
1,15	1,24	P64
1,25	1,34	P50
1,35	1,44	P40
1,45	1,54	P32
1,55	1,64	P25
1,65	1,74	P20
1,75	1,84	P16
1,85	1,94	P12

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 numerical average of the logarithms of exposures, $\log_{10} H_m$, determined from various batches of the product when selected, stored and tested as specified above. 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.

6.1.3 Accuracy

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

6.2 ISO range

6.2.1 ISO range scale

The range scale given in table 2 is derived from the following formula

$$R = (\log_{10} H_S - \log_{10} H_T)$$

where

R is the range;

H_S is the exposure required to produce a density which is 0,90 of net maximum density above base plus fog density;

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H_T is the exposure required to produce a density of 0,04 above base plus fog density.

Points S and T generally correspond to the largest and smallest exposure paper received through an average negative in producing a good print. ($\log_{10}H_S - \log_{10}H_T$) is called log exposure range (LER) (see annex B).

ISO range shall be obtained directly from ($\log_{10}H_S - \log_{10}H_T$) by use of table 2 which shows the rounding method to be used.

Table 2 — ISO range scale

$\log_{10}H_S - \log_{10}H_T$		ISO range
from	to	
0,35	0,44	R40
0,45	0,54	R50
0,55	0,64	R60
0,65	0,74	R70
0,75	0,84	R80
0,85	0,94	R90
0,95	1,04	R100
1,05	1,14	R110
1,15	1,24	R120
1,25	1,34	R130
1,35	1,44	R140
1,45	1,54	R150
1,55	1,64	R160
1,65	1,74	R170
1,75	1,84	R180
1,85	1,94	R190
1,95	2,04	R200

6.2.2 ISO range of a product

The ISO range of a product (as distinguished from that of a specific sample) shall be based on the numerical average of the log exposure range determined from various batches of the product when selected, stored and tested as specified above. The ISO range of a product with proper rounding is determined from the average value of LER by use of table 2.

6.2.3 Accuracy

The calibration of the equipment and processes involved in determining ISO range shall be adequate to ensure the error in LER is less than ± 0,01 or ± 3 %, whichever is greater.

7 Product marking and labelling

7.1 ISO speed

Speed of a product determined by the method described in this International Standard and expressed on the scale of table 1, should be designated ISO speed and denoted in the form of "ISO P100", "ISO speed P100" or "ISO paper speed P100".

7.2 ISO range

Range of a product determined by the method described in this International Standard and expressed on the scale of table 2, should be designated ISO range and denoted in the form of "ISO R140", or "ISO Range 140".

7.3 General

Since the ISO speed and range are not only dependent on the paper product, but also the process used to develop the image, the processing specification should be given whenever possible when quoting values. This should be denoted in the abbreviated form of "ISO P1 000 (D-72)".

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Annex A

Relation between the paper range (R) and the effective density range of the negative

(This annex does not form part of the Standard.)

The log exposure range of a photographic paper provides a useful, but not a perfect, criterion for grading papers. It is useful because a satisfactory print is normally obtained when the log exposure range of a paper is matched to the effective density range of the negative image, provided that the scene and the scene lighting are normal. It is not a perfect criterion because papers with similar log exposure ranges will give prints that differ considerably in appearance if the shapes of the paper sensitometric curves are different. Moreover, a negative which prints well on a glossy paper (high D_{max}) will print equally well on a matte paper coated with the same emulsion (low D_{max}) even though their log exposure ranges will not be the same.

ISO range (R) which is determined directly from the log exposure range is, therefore, a useful guide for selecting a paper for a negative of known density scale. What is involved is the matching of the ISO range (R) with 100 times the effective density range of the negative image. For medium contrast papers, an exact match generally works best. For low contrast papers the LER should be slightly less than the negative density range in most cases and conversely for high contrast papers. This means that to obtain the best prints from a single negative using two papers which differ in D_{max}, it is necessary in most cases for the lower D_{max} (lower contrast) paper to have a smaller LER.

When a negative is contact-printed, its effective density range image equals its diffuse density range as measured by a properly calibrated transmission densitometer (see ISO 5). When an enlarger is employed, the effective negative density range will be greater because of the scattering characteristic (Q-factor[1]) of the negative film. (Stray light typically reduces the density scale by 5 to 10 %). A direct determination of the effective density range of the negative can be made with a photometer by measuring the maximum and minimum illuminance of the projected sharp image on the enlarger easel.

It must also be remembered that optimum print quality depends on aesthetic factors which may indicate the use of a paper whose log exposure range differs considerably from the density range of the negative. Thus, the use of the ISO range/negative density range relationship is only approximate, as a starting point for critical work. The paper range required should be determined for each printed/enlarger, developer, and paper surface combination.

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1) The Callier Q-factor is the ratio of specular density to the diffuse density of a specimen.