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Photography — Digital still cameras — Determination of exposure index, ISO speed ratings, standard output sensitivity, and recommended exposure index

Photographie — Appareils de prises de vue numériques — Détermination de l'indice d'exposition, des régimes de vitesse ISO, de la sensibilité normale de sortie et de l'indice d'exposition recommandé

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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 12232 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 12232:1998), which has been technically revised.

This corrected version incorporates the following corrections:

— the normative reference ISO 7589 has been dated;

— the symbol for the effective *f*-number of the lens has been made consistent in Equations (2), (3) and (4);

— the cross-references in the column headings have been corrected in Table 1;

— Figure A.1 has been changed and notes and footnotes have been added for better clarity;

— Equation (B.1) has been corrected and the symbol for the vignetting factor changed;

— the second paragraph in Annex D has been reworded and changed to a note to reflect its intentional informative nature;

— the second sentence in Table D.1 has been slightly reworded and added at the end of the paragraph preceding Table D.1;

— in Table D.1, zeros have been added to values to improve their readability and the text below the values has been changed to Note 1 to show its intentional informative nature;

— a note has been added to both Figure A.1 and Table D.1 to notify the reader that the decimal sign is a comma in accordance with ISO 31-0;

— ISO 31-0 has been added to the Bibliography and the references have been renumbered accordingly.

Introduction

The ISO speed rating, standard output sensitivity (SOS) and recommended exposure index (REI) are important attributes of digital still cameras (DSCs). Standardization assists users and manufacturers in obtaining proper exposures and in determining the low light capability of DSCs.

The exposure level of a DSC is determined by the exposure time, the lens aperture, the lens transmittance, the level and spectral distribution of the scene illumination, and the scene reflectance. When an image from a DSC is obtained using an insufficient exposure, proper tone reproduction can generally be maintained by increasing the electronic or digital gain, but the image will contain an unacceptable amount of noise. As the exposure is increased, the gain can be decreased, and, therefore, the image noise can normally be reduced to an acceptable level. If the exposure is increased excessively, the resulting signal in bright areas of the image may exceed the maximum signal level capacity of the image sensor or camera signal processing. This can cause the image highlights to be clipped to form a uniformly bright area, or to bloom into surrounding areas of the image. Therefore, it is important to guide the user in setting proper exposures. An ISO speed rating is intended to serve as such a guide. The methods for assigning an ISO speed rating to a DSC harmonize with current film-based photographic standards. In order to be easily understood by photographers, the ISO speed rating for a DSC should directly relate to the ISO speed rating for photographic film cameras. For example, if a DSC has an ISO speed rating of ISO 100, then the same exposure time and aperture should be appropriate for an ISO 100 rated film/process system.

The ISO speed ratings described in this International Standard are intended to harmonize with film ISO speed ratings. However, there are differences between electronic and film-based imaging systems that preclude exact equivalency. DSCs can include variable gain and can provide digital processing after the image data has been captured, enabling desired tone reproduction to be achieved over a range of camera exposures. It is therefore possible for DSCs to have a range of speed ratings. This range is defined as the ISO speed latitude. To prevent confusion, a single value is designated as the ISO speed, with the ISO speed latitude upper and lower limits indicating the speed range.

Photography — Digital still cameras — Determination of exposure index, ISO speed ratings, standard output sensitivity, and recommended exposure index

1 Scope

This International Standard specifies the method for assigning and reporting ISO speed ratings, ISO speed latitude ratings, standard output sensitivity values, and recommended exposure index values, for digital still cameras. This International Standard is applicable to both monochrome and colour digital still cameras.

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 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 7589:2002, *Photography — Illuminants for sensitometry — Specifications for daylight, incandescent tungsten and printer*

ISO 14524, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

IEC 61966-2-1, *Multimedia systems and equipment — Colour measurement and management — Part 2-1: Colour management — Default RGB colour space — sRGB*

ITU-R BT.709, *Parameter values for the HDTV standards for production and international programme exchange*

3 Terms and definitions

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

3.1
digital still camera
DSC
device which incorporates an image sensor and which produces a digital signal representing a still picture

NOTE A digital still camera is typically a portable, hand-held device. The digital signal is usually recorded on a removable memory, such as a solid-state memory card or magnetic disk.

3.2
exposure index
EI
numerical value that is inversely proportional to the exposure provided to an image sensor to obtain an image

NOTE Images obtained from a DSC using a range of exposure index values will normally provide a range of image quality levels.

3.3
exposure series
series of images of the same subject taken using different exposure index values

3.4
image sensor
electronic device that converts incident electromagnetic radiation into an electronic signal

EXAMPLE A charge coupled device (CCD) array.

3.5
ISO speed
numerical value calculated from the exposure provided at the focal plane of a DSC to produce specified camera output signal characteristics using the methods described in this International Standard

NOTE The ISO speed is usually the highest exposure index value that still provides peak image quality for normal scenes. However, a DSC does not necessarily use the ISO speed value as the exposure index value when capturing images.

3.6
ISO speed latitude
set of two numerical values calculated from the exposure provided at the focal plane of a DSC to produce specified camera output signal characteristics using the methods described in this International Standard

NOTE The ISO speed latitude is expected to correlate with the range of exposure index values that provide acceptable image quality for normal scenes.

3.7
photosite integration time
total time period during which the photosites of an image sensor are able to integrate the light from the scene to form an image

3.8
recommended exposure index
REI
specific exposure index value recommended by a DSC provider as a reference for adjusting photographic accessories, as defined in this International Standard

NOTE REI provides a practical exposure index value for setting the reference exposure index of light meters, studio lighting, etc., but images taken using this exposure index value do not necessarily provide the best image quality.

3.9
signal processing
operations performed by electronic circuits or algorithms that convert or modify the output of an image sensor

3.10
standard output sensitivity
SOS
specific exposure index value for a DSC that provides a still image with a specified digital output signal value under specified test conditions, as defined in this International Standard

NOTE SOS provides a practical exposure index value based on the signal level of images captured with a DSC, but images taken using this exposure index value do not necessarily provide the best image quality.

4 Exposure index values

4.1 General

An exposure index (EI) is a numerical value that is inversely proportional to the exposure provided to an image sensor to obtain an image. Images obtained from a DSC using a range of EI values will normally provide a range of image quality levels. The ISO speed of a DSC is equal to a particular exposure index value calculated from the exposure provided at the focal plane of the DSC to produce specified camera output signal characteristics, using the methods described in this International Standard. The equations used in this International Standard have been chosen to create a link between electronic and conventional silver-halide-based photographic systems. Using a particular ISO speed value as the exposure index on a DSC should result in the same camera exposure settings, and resulting focal plane exposures, as would be obtained using the same exposure index on a film camera or other photographic exposure meter.

Where possible, the exposure index values corresponding to the arithmetic mean focal plane exposure used to capture an image should be reported in the image file header as the exposure index.

4.2 Focal plane measurement

For DSC exposure meters, where the arithmetic mean focal plane exposure is measured within a circle lying in the centre of the image with a diameter of 75/100 times the shorter dimension of the image field, the exposure index values, I_{EI}, should be computed using Equation (1), as described in ISO 2721.

$$I_{EI} = 10/H_a \tag{1}$$

where H_a is the arithmetic mean focal plane exposure, expressed in lux-seconds (lx·s).

NOTE 1 The value of 10 as the constant in Equation (1) is consistent with ISO 2721 and ISO 5763. These International Standards assume that the exposure is an arithmetic mean value, as is normally provided by a camera light meter. If the geometric mean exposure was used in place of the arithmetic mean exposure, a lower value for this constant would be appropriate. Note that the arithmetic mean exposure is obtained when the linear exposure values are averaged, while a geometric mean exposure is obtained by taking the antilog of the average of the logarithmic exposure values. An approximation to the geometric mean is also obtained by taking the antilog of the average measured film densities in conventional photographic systems, provided that the film H&D curve has a straight line characteristic over the film exposure range. Note also that the brightness response of the human visual system to the luminances of objects in a scene is approximately logarithmic.

NOTE 2 The arithmetic mean focal plane exposure for statistically average scenes is often assumed to be equal to approximately 18 % of the focal plane exposure, which would be obtained from a perfectly diffuse 100 % reflectance object in a statistically average scene. Therefore, the arithmetic mean focal plane exposure would equal 2/10 times the focal plane exposure that would be obtained from a 90 % reflectance test card in a statistically average scene.

4.3 Scene luminance measurement

For DSC exposure meters where the arithmetic mean scene luminance is measured, the expected value of the arithmetic mean focal plane exposure, H_a, required in Equation (1) can be computed using Equation (2). The derivation of Equation (2) is given in Annex B.

$$H_a = \frac{65 L_a t}{100 A_{eff}^2} \tag{2}$$

where

A_{eff} is the effective f-number of the lens;

L_a is the arithmetic mean luminance, expressed in candelas per square metre;

t is the photosite integration time, expressed in seconds.

NOTE The laboratory measurement of L can be simplified by using a full frame uniformly illuminated diffuse reflecting test card, so that the arithmetic mean luminance can be measured by simply measuring the luminance at the centre of the image.

The effective f-number, A_{eff}, of the lens for the focused image shall be calculated using Equation (3):

$$A_{\text{eff}} = (1 + 1/R)\, f_{\#} \tag{3}$$

where

R is the ratio of the height of the camera field of view at the focus distance to the height of the image at the focal plane;

$f_{\#}$ is the f-number of the lens.

If the camera is focused at infinity, the effective f-number is equal to the f-number of the lens.

Therefore, for electronic still (or other) camera exposure meters where the arithmetic mean scene luminance is measured, exposure index values should be computed using Equation (4), derived by substituting Equation (2) into Equation (1).

$$I_{\text{EI}} = \frac{154 A_{\text{eff}}^2}{10 L_{\text{a}} t} \tag{4}$$

5 Test conditions

5.1 General

The following measurement conditions should be used as nominal conditions when determining the ISO speed ratings, SOS, and REI values of a DSC. If it is not possible or appropriate to achieve these nominal operating conditions, the actual operating conditions shall be listed along with the reported values.

5.2 Illumination

The reported values shall indicate whether the daylight or tungsten illuminant was used. ISO 7589 describes the procedures for determining if the illumination used in a specific speed rating determination test is an acceptable match to the daylight and tungsten sensitometric illuminants.

5.2.1 Daylight illumination

For daylight measurements without the camera lens, the ISO sensitometric daylight illuminant given in Table 1 of ISO 7589:2002 shall be used. This illuminant is defined as the product of the spectral power distribution of CIE colorimetric standard illuminant D_{55} and the spectral transmittance of the International Standard camera lens. For measurements with the camera lens in place, the spectral radiance characteristics of the light used for the measurement should be equivalent to the daylight ISO standard source provided in the second column of Table 1 of ISO 7589:2002. In order to apply the ISO SDI (spectral distribution index) criterion, the spectral radiance of the light shall be measured and then multiplied by the relative spectral transmittance of the ISO standard lens, which is also described in ISO 7589, prior to multiplying by the weighted spectral sensitivities.

5.2.2 Tungsten illumination

For tungsten measurements without the camera lens, the ISO sensitometric studio tungsten illuminant given in Table 2 of ISO 7589:2002 shall be used. This illuminant is defined as the product of the average spectral power distribution of experimentally measured sources having a colour temperature of approximately 3 050 K and the spectral transmittance of the International Standard camera lens. For measurements with the camera lens in place, the spectral radiance characteristics of the light used for the measurement should be equivalent

to the tungsten ISO standard source provided in the second column of Table 2 of ISO 7589:2002. In order to apply the ISO SDI (spectral distribution index) criterion, the spectral radiance of the light shall be measured and then multiplied by the relative spectral transmittance of the ISO standard lens, which is also described in ISO 7589, prior to multiplying by the weighted spectral sensitivities.

5.3 Temperature and relative humidity

The ambient temperature during the acquisition of the test data shall be (23 ± 2) °C, as specified in ISO 554, and the relative humidity should be (50 ± 20) %.

5.4 White balance

For a colour camera, the camera white balance should be adjusted, if possible, to provide proper white balance (equal RGB signal levels) for the illumination light source, as specified in ISO 14524.

5.5 Infrared (IR) blocking filter

If required, an infrared (IR) blocking filter shall be used as specified in ISO 14524.

5.6 Photosite integration time

The photosite integration time should not be longer than 1/30 s.

5.7 Compression

If the DSC includes any form of lossy compression, the compression shall be disabled, if possible, during the determination of $\sigma(D_H)$ or $\sigma(D_L)$ in Clause 6. If it is not possible to disable the camera compression, the noise-based values cannot be properly determined, and shall not be reported.

5.8 Other DSC user settings

All other camera controls (e.g. sharpness, contrast) shall be set to the factory default settings. Additional, optional, measurements can also be made using camera control settings that are not the factory default settings, for example with the DSC set to monochrome mode. However, the reporting of such optional measurements shall be done in a manner that does not cause confusion with the primary measurements made using the factory default settings.

6 Determination of ISO speed

6.1 General

With appropriate electrical or digital gain, a DSC can provide an appropriate output signal level for a range of sensor exposure levels. The maximum exposure level is the exposure level where typical picture highlights will be clipped as a result of saturating the image sensor signal capacity or reaching the camera signal processing maximum signal level. The minimum exposure level depends on the amount of noise that can be tolerated in the image. These situations lead to two different types of speed values, saturation signal-based values and noise-based values. The ISO speed is preferably determined using a noise-based method. The saturation-based value is preferably used to indicate the camera's overexposure speed latitude. A second noise-based value is preferably used to indicate the camera's underexposure speed latitude. For some types of DSCs, such as those employing lossy compression methods, it is not possible to correctly determine the noise-based ISO speed. In such cases, the ISO speed of the camera is determined using the saturation-based measurement, and the ISO speed latitude values are not reported. In other cases, the noise-based ISO speed may be lower than the saturation-based speed, in which case the saturation based-speed is reported.