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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.

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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.

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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, *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.

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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 needs 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.

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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.

$$I_{\mathrm{EI}} = 10/H_{\mathrm{a}} \tag{1}$$

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 required in Equation (1) can be computed using Equation (2). The derivation of Equation (2) is given in Annex B.

$$H_{\mathrm{a}} = \frac{65\, L_{\mathrm{a}} t}{100\, A^2} \tag{2}$$

where

A 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.

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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, $N_{f\text{eff}}$, of the lens for the focused image shall be calculated using Equation (3):

$$N_{f\text{eff}} = (1 + 1/R)\, N_{f\text{lens}} \tag{3}$$

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. 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).

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

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.

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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.

6.2 Saturation-based speed

In photographic applications where the scene illumination level can be controlled, for example in studio photography, the photographer normally prefers to use a camera exposure index which provides the best possible image quality. In this situation, a saturation signal-based rating is appropriate. This rating allows the

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user to set the camera exposure so that typical image highlights are just below the maximum possible (saturation) camera signal value.

6.2.1 Focal plane measurement

The saturation based speed, S_{sat}, of an electronic still picture camera is defined as:

$$S_{\text{sat}} = 78/H_{\text{sat}} \tag{5}$$

where H_{sat} is the minimum focal plane exposure, expressed in lux-seconds (lx·s), that produces the maximum valid (not clipped or bloomed) camera output signal.

NOTE Equation (5) provides 1/2 "stop" of headroom (41 % additional headroom) for specular highlights above the signal level that would be obtained from a theoretical 100 % reflectance object in the scene, so that a theoretical 141 % reflectance object in the scene would produce a focal plane exposure of H_{sat}. Therefore, an 18 % reflectance test card in the scene would produce a focal plane exposure of 128/1 000 H_{sat}. Thus, the multiplicative constant 78 in Equation (5) is equal to 10 times 1 000/128, where the value 10 is the constant from Equation (1).

6.2.2 Scene luminance measurement

If the focal plane exposure of the DSC cannot be measured directly, it shall be computed from the scene luminance using Equation (2).

6.3 Noise-based speed

In many photographic applications, it is desirable to use the highest exposure index (i.e. the lowest exposure) possible, in order to maximize the depth of field, minimize the exposure time, and offer the maximum acceptable latitude for exposure of image highlights. An exposure index that provides an appropriately low noise image for a typical DSC is called a "noise-based speed". The value is based on an objective correlation to subjective judgements of the acceptability of various noise levels in exposure series images. Two different noise-based speeds are determined, one (S_{noise40}) that provides the "first excellent" image and a second (S_{noise10}) that provides the "first acceptable" image. The recommended procedure for determining these noise-based speeds is given in Annex A.

6.3.1 Focal plane method

The two noise-based speeds of a DSC, S_{noise40} and S_{noise10}, shall be determined from the focal plane exposure required to produce specific image incremental signal-to-noise (S/N) ratio values, measured using linearized output signals from the DSC, using the following equations (see Note 1):

$$S_{\text{noise40}} = 10/H_{S/N40} \tag{6}$$

$$S_{\text{noise10}} = 10/H_{S/N10} \tag{7}$$

where $H_{S/N40}$ is the exposure that provides DSC output signals which, when linearized, satisfy the equation:

$$D = 40\ \sigma(D), \tag{8}$$

and $H_{S/N10}$ is the exposure that provides DSC output signals which, when linearized, satisfy the equation:

$$D = 10\ \sigma(D), \tag{9}$$

where

H is the input photometric exposure, in lux-seconds, needed to produce the linearized luminance signal level D;

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$\sigma(D)$ is the standard deviation of the linearized monochrome output level values at the linearized signal level D (for monochrome cameras) or standard deviation of the linearized, weighted colour DSC output values (for colour cameras, as provided in 6.2.3), taken from a 64 by 64 pixel area (see Note 2).

The DSC output signals shall be linearized in accordance with ISO 14524 and the linearized values shall be filtered using the filter provided in Annex D prior to determining $\sigma(D)$.

NOTE 1 The constants used in the numerator of Equations (6) and (7) place the specified signal-to-noise ratio at a middle grey image tone, or approximately an 18 % reflectance value for a standard 160:1 contrast ratio scene.

NOTE 2 If there is not a significant effect on the resulting S/N, a smaller or larger area is allowable.

NOTE 3 The S/N values of 40 for the “first excellent” image and 10 for the “first acceptable” image were determined using subjective experiments performed during the development of this International Standard. These incremental signal-to-noise ratios were judged to provide “excellent” and “acceptable” quality prints of typical pictorial images using a high quality printer at approximately 70 sensor pixels/cm on the print (just small enough to be visually imperceptible) using normal tone reproduction. Note that 70 pixels/cm at a standard viewing distance of 25 cm corresponds to 30 pixels per degree of visual subtense. For prints made using significantly higher sensor pixels per centimetre values, lower S/N values may still yield acceptably low noise prints, while for prints made using significantly lower sensor pixels per centimetre values, higher S/N values may be required to provide acceptably low noise prints. In these cases, the S/N value for “excellent” quality prints is approximately equal to (70/P) times the S/N values listed, where P is the actual number of sensor pixels per centimetre on the print.

If a DSC is too noisy to meet the $H_{S/N40}$ criterion, the saturation based value shall be reported as the ISO speed of the DSC.

6.3.2 Scene luminance method

If the focal plane exposure of the DSC cannot be measured directly, it shall be computed from the scene luminance using Equation (2).

6.3.3 Colour cameras

The noise of the luminance and colour difference signals shall be determined from CRT display output-referred RGB colour signals based on the ITU-R BT.709 RGB primaries and white point, such as the sRGB and sYCC signals defined in IEC 61966-2-1, which are used as output signals in many DSCs.

For colour cameras using a single exposure process, $\sigma(D)$ shall be determined using the linearized DSC output signals. If the DSC provides CRT display output-referred RGB colour signals based on the ITU-R BT.709 primaries and white point, these signals shall be converted to linearized RGB signals in accordance with ISO 14524. If the DSC encodes these RGB signals as Y, Cr, Cb output signals, the signals shall be decoded to provide RGB output signals using the inverse of the matrix used to encode the signals. The decoded RGB output signals shall then be converted to linearized RGB signals in accordance with ISO 14524.

If the DSC colour output signals are not CRT display output-referred RGB colour signals based on the ITU-R BT.709 primaries and white point, they shall be converted to the required signals, using an appropriate colour space conversion and rendering process if necessary, prior to performing the noise analysis.

The linearized luminance signal shall be formed from the linearized RGB signals using the equation:

$$Y = (2\,125/10\,000\ R) + (7\,154/10\,000\ G) + (721/10\,000\ B) \qquad (10)$$

The standard deviation of the camera noise, $\sigma(D)$ shall be computed using the following equation:

$$\sigma(D) = \{\ \sigma(Y)^2 + [279/1\,000\ \sigma(R-Y)^2] + [88/1\,000\ \sigma(B-Y)^2]\}^{1/2} \qquad (11)$$

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6.3.4 Quantization effects

If the DSC has quantization steps which are similar in magnitude to, or larger than, the measured standard deviation, quantization effects may result in the measured standard deviation being incorrect. This type of error may be corrected to some extent by repeated measurements on different image files, but if the actual standard deviation is small, even repeated measurements may result in the value determined being too low. To compensate for this effect, the value of $\sigma(H)$ or $\sigma(L)$ used in Equations (10) and (11) shall be not less than 1/2.

NOTE The value of 1/2 is greater than the standard deviation of noise from uniform quantization, which equals the square-root of 1/12. The value of 1/2 has been chosen because if the measured standard deviation is below this value, the measured values are significantly influenced by quantization effects and are no longer meaningful.

6.4 Method of reporting

The ISO speed of a DSC shall be denoted “ISO xxx D” (or alternatively “ISO xxx”) for daylight illumination and “ISO xxx T” for tungsten illumination. If S_{noise40} is higher than S_{sat}, the reported number “xxx” shall be the value from the third column of Table 1 from the same row as the S_{noise40} value (in the second column of Table 1) determined in 6.2. The ISO speed latitude shall be denoted “ISO Speed Latitude yyy - zzz D” (or alternatively “ISO Speed Latitude yyy – zzz:”) for daylight illumination and “ISO Speed Latitude yyy - zzz T” for tungsten illumination. The reported number “yyy” shall be the value from the third column of Table 1 from the same row as the S_{sat} value (in the first column of Table 1) determined in 6.1. The reported number “zzz” shall be the value from the third column of Table 1 from the same row as the S_{noise10} value determined in 6.2.

If S_{noise40} is lower than c, or if S_{noise40} cannot be determined because the noise level of the camera does not allow for a $S/N = 40$ value, the ISO speed of the camera shall be denoted “ISO yyy D” (or alternatively “ISO xxx”) for daylight illumination and “ISO yyy T” for tungsten illumination, where “yyy” is the speed rating from Table 1 corresponding to the ISO sat value determined in 6.1. The reported number “yyy” shall be the value from the third column of Table 1 from the same row as the S_{sat} value (in the first column of Table 1) determined in 6.1. The ISO speed latitude shall be denoted as described in the preceding paragraph, unless the S_{noise10} value is lower than the S_{sat} value, or the noise level of the camera does not allow for a $S/N = 10$ value, in which case an ISO speed latitude shall not be reported.

Some DSCs form a colour image using a monochrome image sensor and a colour filter wheel to provide colour sequential image records. These cameras may use different photosite integration times, or different lens apertures, for the different colour sequential exposures. For such cameras, the ISO speed and ISO speed latitude of each colour should be measured and reported separately for each colour.

The ISO speed ratings reported in image file headers shall conform to the reporting requirements outlined above. Since the user controls on DSC adjust the exposure index used to capture each image, as defined in Clause 4, rather than the ISO speed of the DSC, the user controls should be labelled as “exposure index” or “exposure setting” controls, rather than as “ISO speed” controls.

7 Determination of standard output sensitivity (SOS)

The “standard output sensitivity” (SOS) is the exposure index value (I_{SOS}) for a DSC that provides a still image with a specified digital output signal value under specified test conditions. Unique SOS values can only be determined for DSC operational modes where the electronic or digital gain is fixed, and therefore the DSC SOS shall be reported as “variable” for DSC operational modes where the electronic or digital gain is variable. However, in this case, the I_{SOS} corresponding to the gain or digital processing used to create a particular image file may be reported in the file header, and the range of I_{SOS} values a particular DSC can produce may be reported.

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7.1 Method for calculating SOS

The SOS (I_{SOS}) shall be computed using the following equation:

$$I_{SOS} = 10/H_{SOS} \tag{12}$$

where H_{SOS} is the exposure required to produce the specified standard level digital signal output equal to

$$461/1\,000 \times O_{MAX} \tag{13}$$

where O_{MAX} is the maximum output value of the digital system. For 8-bit systems, the reference level shall be 118.

The test conditions shall be as specified in Clause 5. Recommendations for determining I_{SOS} values are provided in Annex C. If a camera OECF chart is used to determine SOS values, the illumination level should be 2 000 lx at the chart surface for reflection test charts, and 637 cd/m^2 for the most transparent portions of transparency charts.

If the DSC includes a user controlled sensitivity setting, it shall be set to one or more specific levels, which shall be reported along with the measurement results.

7.2 Method of reporting

The value calculated using Equation (12) shall be rounded off using Table 1, and reported as the "Standard Output Sensitivity (I_{SOS}). A "D" or descriptive term such as "Daylight" can be used to designate daylight illumination, but is not required. A "T" or descriptive term such as "Tungsten" shall be used to designate tungsten illumination. An example of acceptable reporting is as follows:

ISO sss (SOS/Daylight)

It is possible that the I_{SOS} value changes as a function of the f/number of the lens, for example due to the structure of a microlens overlay on the image sensor. In such cases, the f/number used for the measurement shall be reported along with the I_{SOS} value.

8 Specification of recommended exposure index (REI)

The DSC recommended exposure index (I_{REI}) is a numerical value that is recommended by the DSC provider as a reference. The I_{REI} can be used to provide appropriate settings for photographic accessories, such as exposure meters and strobe lights.

When the DSC includes a manual exposure mode, or includes an exposure mode using a simple automatic exposure function, then the I_{REI} value is useful. However, when the DSC includes only a sophisticated automatic exposure function, which adjusts the exposure level based on the subject pattern or the absolute luminance range in the scene, the I_{REI} value in not useful and should not be reported.

8.1 Method for calculating recommended exposure index

The DSC recommended exposure index shall be computed using the following equation:

$$I_{REI} = 10/H_m \tag{14}$$

where H_m is the arithmetic mean focal plane exposure, expressed in lux-seconds, recommended by the DSC provider.

If the recommended exposure index varies as a function of camera mode settings or environmental conditions, these factors shall be reported. Unless otherwise indicated, the default camera mode settings and the environmental settings provided in Clause 5 shall be used.

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The H_m should be reported for both daylight and tungsten illumination.

8.2 Method of reporting

The value calculated using Equation (14) shall be rounded off using Table 1, and reported as the "recommended exposure index" (I_{REI}). A "D" or descriptive term such as "Daylight" can be used to designate daylight illumination, but is not required. A "T" or descriptive term such as "Tungsten" shall be used to designate tungsten illumination. An example of acceptable reporting is as follows:

ISO rrr (REI/Daylight)

Table 1 — ISO speed, ISO speed latitude, SOS and REI reported values

S_{sat} (from 6.1)	S_{noise} (from 6.2)	I_{SOS} and I_{REI}	Reported value
$8 < S_{sat} < 10$	$10 < S_{noise} < 12$	$8{,}909 < x < 11{,}22$	10
$10 < S_{sat} < 12$	$12 < S_{noise} < 16$	$11{,}22 < x < 14{,}14$	12
$12 < S_{sat} < 16$	$16 < S_{noise} < 20$	$14{,}14 < x < 17{,}82$	16
$16 < S_{sat} < 20$	$20 < S_{noise} < 25$	$17{,}82 < x < 22{,}45$	20
$20 < S_{sat} < 25$	$25 < S_{noise} < 32$	$22{,}45 < x < 28{,}28$	25
$25 < S_{sat} < 32$	$32 < S_{noise} < 40$	$28{,}28 < x < 35{,}64$	32
$32 < S_{sat} < 40$	$40 < S_{noise} < 50$	$35{,}64 < x < 44{,}90$	40
$40 < S_{sat} < 50$	$50 < S_{noise} < 64$	$44{,}90 < x < 56{,}57$	50
$50 < S_{sat} < 64$	$64 < S_{noise} < 80$	$56{,}57 < x < 71{,}27$	64
$64 < S_{sat} < 80$	$80 < S_{noise} < 100$	$71{,}27 < x < 89{,}09$	80
$80 < S_{sat} < 100$	$100 < S_{noise} < 125$	$89{,}09 < x < 112{,}2$	100
$100 < S_{sat} < 125$	$125 < S_{noise} < 160$	$112{,}2 < x < 141{,}4$	125
$125 < S_{sat} < 160$	$160 < S_{noise} < 200$	$141{,}4 < x < 178{,}2$	160
$160 < S_{sat} < 200$	$200 < S_{noise} < 250$	$178{,}2 < x < 224{,}5$	200
$200 < S_{sat} < 250$	$250 < S_{noise} < 320$	$224{,}5 < x < 282{,}8$	250
$250 < S_{sat} < 320$	$320 < S_{noise} < 400$	$282{,}8 < x < 356{,}4$	320
$320 < S_{sat} < 400$	$400 < S_{noise} < 500$	$356{,}4 < x < 449{,}0$	400
$400 < S_{sat} < 500$	$500 < S_{noise} < 640$	$449{,}0 < x < 565{,}7$	500
$500 < S_{sat} < 640$	$640 < S_{noise} < 800$	$565{,}7 < x < 712{,}7$	640
$640 < S_{sat} < 800$	$800 < S_{noise} < 1\,000$	$712{,}7 < x < 890{,}9$	800
$800 < S_{sat} < 1\,000$	$1\,000 < S_{noise} < 1\,250$	$890{,}9 < x < 1\,122$	1 000
$1\,000 < S_{sat} < 1\,250$	$1\,250 < S_{noise} < 1\,600$	$1\,122 < x < 1\,414$	1 250
$1\,250 < S_{sat} < 1\,600$	$1\,600 < S_{noise} < 2\,000$	$1\,414 < x < 1\,782$	1 600
$1\,600 < S_{sat} < 2\,000$	$2\,000 < S_{noise} < 2\,500$	$1\,782 < x < 2\,245$	2 000
$2\,000 < S_{sat} < 2\,500$	$2\,500 < S_{noise} < 3\,200$	$2\,245 < x < 2\,828$	2 500
$2\,500 < S_{sat} < 3\,200$	$3\,200 < S_{noise} < 4\,000$	$2\,828 < x < 3\,564$	3 200
$3\,200 < S_{sat} < 4\,000$	$4\,000 < S_{noise} < 5\,000$	$3\,564 < x < 4\,490$	4 000
$4\,000 < S_{sat} < 5\,000$	$5\,000 < S_{noise} < 6\,400$	$4\,490 < x < 5\,657$	5 000
$5\,000 < S_{sat} < 6\,400$	$6\,400 < S_{noise} < 8\,000$	$5\,657 < x < 7\,127$	6 400
$6\,400 < S_{sat} < 8\,000$	$8\,000 < S_{noise} < 10\,000$	$7\,127 < x < 8\,909$	8 000

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Annex A
(informative)

Recommended procedure for determining the noise-based ISO speed

The value of H in Equation (6) or (7) may be determined by plotting the incremental S/N as a function of H, and estimating the value that produces an incremental S/N value equal to 40 for S_{noise40} and 10 for S_{noise10}. A preferred procedure for making this determination for colour DSCs is as follows.

a) Obtain DSC output RGB values either directly, or by converting the camera's Y, Cb Cr signals to RGB signals using the inverse of the RGB to Y, Cb, Cr encoding equations.

b) Determine the system OECF in accordance with ISO 14524. Focal plane OECF values are preferred, although alternative focal plane values may be used for cameras with fixed lenses, and camera OECF values may be used for cameras with fixed lenses and non-overrideable automatic exposure control. Convert the DSC RGB output signals into linearized RGB signals.

c) Calculate linearized Y, R-Y, and B-Y image data using Equation (10). It is usually necessary to add an offset in calculating the R-Y, and B-Y difference channels to prevent the difference values from wrapping around zero. Wrapped values will produce incorrectly low standard deviation values.

d) Determine the standard deviation of the pixel values in each 64 by 64 area selected for the OECF measurement, using Equation (11).

e) Calculate the signal-to-noise values as a function of the exposure H. Determine the values of H that produce signal-to-noise values of 10 and 40. Use Equations (6) and (7) to determine the ISO noise-based speeds. Use Table 1 to determine the reported value.

Figure A.1 shows an example plot of the weighted colour signal to noise ratio (CSNR) versus exposure (H), in lux-seconds. The CSNR = 40 intercept is 68/1 000 lx·s, corresponding to an ISO speed reported value of 125. The CSNR = 10 intercept is 8/1 000 lx·s, corresponding to an ISO speed latitude upper limit reported value of 1 250.

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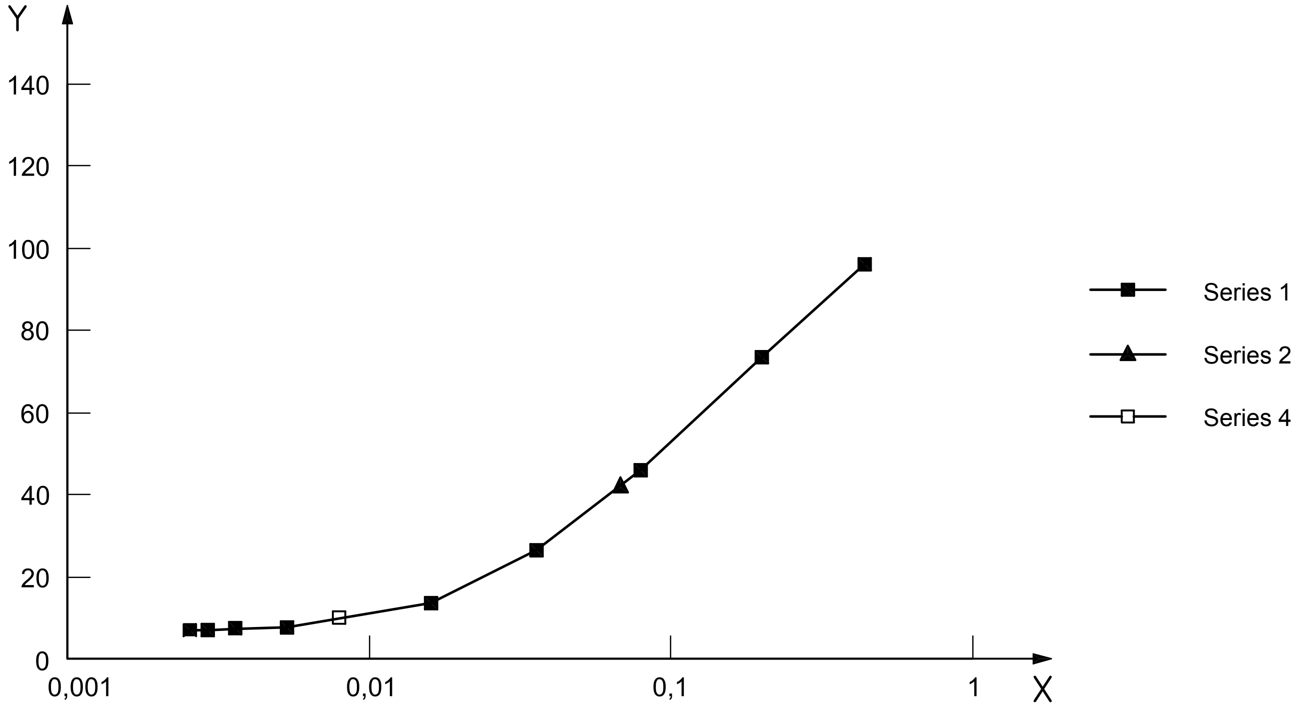

Key

X Exposure H, lux-seconds

Y Signal-to-noise ratio, CSNR

Figure A.1 — Example plot of incremental signal to noise ratio versus exposure

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Annex B
(informative)

Scene luminance and focal plane exposure

This annex describes the mathematical basis of Equation (2) of this International Standard. The fundamental relationship between the scene luminance and the focal plane exposure is expressed by Equation (B.1):

$$H = \frac{\pi T f_{\mathrm{v}} \cos^4(\theta) L t F^2}{4 A^2 i^2} + H_{\mathrm{f}} = \frac{q L t F^2}{4 A^2 i^2} + H_{\mathrm{f}} \tag{B.1}$$

where

q is equal to $(\pi/4)\, T f_{\mathrm{v}} \cos^4(\theta)$;

A is the lens f-number;

F is the lens focal length, expressed in meters;

H is the focal plane exposure, expressed in general in lux-seconds;

H_{f} is the focal plane flare exposure, expressed in lux-seconds;

i is the image distance, expressed in meters;

L is the scene luminance, expressed in candelas per square meter;

T is the transmission factor of the lens;

t is the exposure time, expressed in seconds;

f_{v} is the vignetting factor;

θ is the angle of image point off axis.

When the camera is focused on infinity, $H_{\mathrm{f}} \ll H$, T = 9/10, θ = 10°, $\cos^4\theta$ = 94/100, and f_{v} = 98/100, q is equal to 65/100, and Equation (B.1) reduces to:

$$H_{\mathrm{a}} = \frac{65 L_{\mathrm{a}} t}{100\, A^2} \tag{B.2}$$

as given in Equation (2), where L_{a} is the arithmetic mean luminance.

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Annex C
(informative)

Recommended procedure for determining SOS values

C.1 Measure the focal plane OECF in accordance with ISO 14524

C.1.1 If the DSC exposure settings can be set manually, the focal plane or alternative focal plane measurement methods may be used.

C.1.2 If it is not possible to disable autoexposure, but the exposure settings used are accurately reported by the DSC, the camera OECF may be measured, and the scene luminance values converted to focal plane exposure values using Equation (B.2). If this method is used, a low contrast (20:1) OECF chart is recommended to minimize the effect of flare, with the chart illumination as specified in 7.1 of this International Standard.

C.1.3 When it is not possible to disable autoexposure, care should be taken to ensure that camera analog and digital gains are fixed, as sometimes it is difficult to distinguish between autoexposure and autogain.

C.1.4 If autogains are used, it may still be possible to determine and report the limiting SOS values.

C.2 Determine the SOS

C.2.1 Take the base ten logarithm of the focal plane exposure values.

C.2.2 Interpolate the log exposure value log[H_{sos}] at the reference level using linear interpolation between the log exposure values and the DSC output digital values.

C.2.3 Take the antilog of log[H_{sos}] and determine the I_{SOS} using Equation (12).

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Annex D
(normative)

Removing low frequency variations from the image data

When determining the noise-based ISO speed, the linearized image data shall be pre-processed to remove non-uniformities (such as lens fall-off or test chart illumination non-uniformity) before measuring the Y, R-Y and B-Y standard deviations. This shall be accomplished by applying the high pass filter specified in this annex to the Y, R-Y, and B-Y colour planes. This 13 × 13 finite impulse response (FIR) spatial filter passes all but the lowest spatial frequencies.

The lenses in many DSCs exhibit a slowly varying centre to edge intensity roll off. This non-uniformity shall be removed from the digital image data before measuring the noise, since it degrades (increases) the measured noise standard deviations and reduces the measured noise-based ISO speed.

The following 13 × 13 tap FIR filter is convolved with the Y, R-Y, and B-Y image data to remove the low frequency variations from the image data. The spatial frequency response of this FIR filter greatly attenuates the lowest image spatial frequencies, including the lens non-uniformity. Table D.1 displays the bottom-right quadrant of the 13 × 13 kernel that shall be used prior to computing $\sigma(D)$. The whole 13 × 13 kernel is defined by reflecting the bottom 6 rows about the first row, and then reflecting that result about the first column. Since the table values are redundant and symmetric, only the bottom right quadrant is specified here.

Table D.1 — High pass filter kernel (lower right quadrant)

0,996 926	−0,006 47	−0,007 4	−0,006 09	−0,009 6	−0,003 82	−0,009 64
−0,006 47	−0,006 64	−0,012 23	−0,005 8	−0,007 3	−0,005 48	−0,008 93
−0,007 4	−0,012 23	−0,001 73	−0,009 89	−0,005 71	−0,007 06	−0,007 18
−0,006 09	−0,005 8	−0,009 89	−0,007 92	−0,003 56	−0,009 76	−0,003 59
−0,009 6	−0,007 3	−0,005 71	−0,003 56	−0,009 64	−0,006 54	0,000 124
−0,003 82	−0,005 48	−0,007 06	−0,009 76	−0,006 54	−0,000 44	0,000 412
−0,009 64	−0,008 93	−0,007 18	−0,003 59	0,000 124	0,000 412	−0,000 13
This 13 × 13 FIR filter removes the DC component of the image, and thus the mean signal value D cannot be computed from the filter output values. Care should be taken to ensure that negative filter output values are not clipped to zero prior to computing $\sigma(D)$.						

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Annex E
(informative)

Calculation of noise-based minimum illumination level

The $S_{noise10}$ value described in 6.2 can be converted to a minimum scene illumination level using the Equation (E.1):

$$E_{min} = 270\, A_{min}^2 / (S_{noise10} \times t_{std}) \tag{E.1}$$

where

E_{min} is the minimum noise-based scene illumination level, expressed in lux;

$S_{noise10}$ is determined as described in 6.2;

A_{min} is the lowest f-number of the lens;

t_{std} is either 1/30 second or the slowest camera exposure time, whichever is shorter.

Note that this rating is applicable only to DSCs. The acceptable noise level for a video camera may be a different value.

NOTE The value of 270 for the constant is obtained using Equations (2) and (7), and using the conversion

$E_{min} = L_{min} \times 314/18$

where

E_{min} is the scene illumination level, in lux, that produces a luminance level of L_{min} when illuminating an 18 % reflectance diffuse reflecting object;

L_{min} is the luminance, in cd·m^2, from an 18 % reflectance diffuse reflecting object.

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Bibliography

[1] ISO 6, *Photography — Black-and-white pictorial still camera negative film/process systems — Determination of ISO speed*

[2] ISO 2240, *Photography — Colour reversal camera films — Determination of ISO speed*

[3] ISO 2720, *Photography — General purpose photographic exposure meters (photoelectric type) — Guide to product specification*

[4] ISO 2721, *Photography — Cameras — Automatic controls of exposure*

[5] ISO 5763, *Photography — Electronic flash equipment — Automatic control of exposure*

[6] ISO 5800, *Photography — Colour negative films for still photography — Determination of ISO speed*

[7] ISO 7187, *Photography — Materials for direct-positive colour-print cameras — Determination of ISO speed*

[8] ISO 10157, *Photography — Flash exposure meter — Requirements*

[9] IEC 61146-1, *Video cameras (PAL/SECAM/NTSC) — Methods of measurement — Part 1: Non-broadcast single-sensor cameras*

[10] HOLM, J. Exposure-speed relations and tone reproduction. *IS&T's 47th Annual Conference/ICPS*, Vol. II, 1994, pp. 641-648

[11] HOLM, J. and SUSSTRUNK, S. An EIQ-subjective image quality correlation study, *IS&T's 47th Annual Conference / ICPS*, vol. II, 1994, pp. 634-640

[12] HOLM, J. The photographic sensitivity of electronic still cameras. *J. of the Society of Photographic Science and Technology of Japan*, pp. 117-131, No. 1, 1996

[13] JONES, L.A. The evaluation of negative film speeds in terms of print quality. *J. of the Franklin Institute*, **227** (3), Mar. 1939, pp. 297-354

[14] JONES, L.A. and CONDIT, H.R. The brightness scale of exterior scenes and the computation of correct photographic exposure. *J. of the Optical Society of America*, **31** (11), Nov. 1941, pp. 651-678

[15] JUENGER, A.K. and HIGGINS, E.W. A graininess metric for electronic still photography. *IS&T's 46th Annual Conference*, 1993, pp. 408-410

[16] KELLY, S.C. and KEELAN, B.W. ISO 12232 revision: determination of chrominance noise weights for noise-based ISO calculation, *Proc. SPIE*, **5668**, 2005, pp. 139-147

[17] SCUDDER, J.F., NELSON, C.N. and STIMSON, A. Re-evaluation of factors affecting manual or automatic control of camera exposure. *J. SMPTE*, **77**, 1968, pp. 24-26

[18] VIETH, G. On the automatic exposure of photographic camera films. *Journal of Applied Photographic Engineering*, **4** (2), Spring 1978, pp. 57-61

[19] ZWICK, D.M. The technical basis of photographic speed determination, or what is a normal exposure. *SMPTE Journal*, **88** (8), Aug. 1979, pp. 533-537

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