
**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*



STANDARDSISO.COM : Click to view the full PDF of ISO 12232:2019



COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Exposure index	3
4.1 General	3
4.2 Focal plane measurement	4
4.3 Estimating focal plane exposure from scene luminance	4
5 Test conditions	4
5.1 General	4
5.2 Illumination	4
5.2.1 Daylight reference illuminant	5
5.2.2 Tungsten reference illuminant	5
5.3 Temperature and relative humidity	5
5.4 White balance	5
5.5 Infrared (IR) blocking filter	5
5.6 Photosite integration time	5
5.7 Compression	5
5.8 Other DSC user settings	5
6 Determination of ISO speed and ISO speed latitude	6
6.1 General	6
6.2 Saturation-based calculations	6
6.2.1 Focal plane measurement	6
6.2.2 Scene luminance measurement	7
6.3 Noise-based calculations	7
6.3.1 Focal plane method	7
6.3.2 Scene luminance method	8
6.3.3 Colour cameras	8
6.3.4 Quantization effects	8
6.4 Method of reporting	9
7 Determination of standard output sensitivity (SOS)	11
7.1 Method for calculating SOS	11
7.2 Method of reporting	12
8 Specification of recommended exposure index (REI)	12
8.1 General	12
8.2 Method for calculating recommended exposure index	12
8.3 Method of reporting	12
Annex A (informative) Recommended procedure for determining the noise-based ISO speed	15
Annex B (informative) Scene luminance and focal plane exposure	17
Annex C (informative) Recommended procedure for determining SOS values	19
Annex D (normative) Removing low frequency variations from the image data	20
Bibliography	21

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 12232:2006), which has been technically revised.

The main changes compared to the previous edition are as follows:

- definitions of photographic sensitivity and sensitivity setting were added;
- [Clause 4](#) was simplified and clarified;
- it has been defined how to determine the exposure saturation level in [6.2](#);
- the applicability of SOS values for scene-dependent rendering and raw files was clarified;
- original [Table 1](#) was expanded to include higher values, and separated the SOS and REI columns into a new [Table 2](#), which includes alternate values for some of the rows;
- [Annex B](#) was updated to clarify the mathematical basis of [Formula \(2\)](#);
- Annex E was cancelled.

Introduction

The exposure index (EI), ISO speed ratings, standard output sensitivity (SOS) and recommended exposure index (REI) are useful metrics related to the capture of digital images. Standardization assists users and manufacturers in determining the capabilities of Digital Still Cameras (DSCs), in setting DSCs appropriately for the capture conditions, in obtaining well-exposed images, and in communicating exposures and the related DSC characteristics in image files.

The exposures produced by a DSC are determined by the exposure time, the lens aperture, the lens transmittance, the lens illumination falloff, the flare light present at the sensor, and the level and spectral distribution of the scene radiances incident on the camera lens. However, it is not typical for users to deal with this degree of complexity when determining and specifying image exposures. To provide a means for simply communicating exposure information, this document specifies an exposure index (EI) that corresponds to the focal plane exposure of a typical mid-tone. It is intended to be used for setting the camera exposure and as a record of the camera exposure in image files.

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 know the EI that will on-average produce the best image quality for specific DSC settings, and the range of EIs over which the DSC can be expected to produce acceptable image quality. The ISO speed and speed latitude ratings are intended to provide such information.

This document was designed to harmonize with earlier standards developed for film-based photography. For example, the equations were chosen so that using a particular EI on a DSC should result in approximately the same camera exposure settings, and resulting focal plane exposures, as would be obtained using the same EI on a photographic film camera. For example, the value of 10 as the constant in [Formula \(1\)](#) of this document is consistent with ISO 2721, so as to harmonize with this earlier ISO standard for photographic film cameras. ISO 2721 uses the term nominal exposure and assumes that the nominal exposure is an arithmetic mean exposure value, which usually corresponds to the mid-tone in photographs of average scenes.

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 ISO 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.

It can also be useful to compare or record the sensitivity of a DSC, for cases where the DSC has a fixed sensitivity. The standard output sensitivity (SOS) is designed to meet this need. Likewise, it can be useful to know the EI recommended by the DSC manufacturer for a specific condition. This information is provided by the recommended exposure index (REI).

STANDARDSISO.COM : Click to view the full PDF of ISO 12232:2019

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

1 Scope

This document 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. It is applicable to both monochrome and colour digital still cameras.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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)*

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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

digital still camera

DSC

device which incorporates an image sensor and which produces digital image data representing a still picture

Note 1 to entry: A digital still camera is typically a portable, hand-held device. The device can provide additional functions, for example video image capture or wireless telephony. The digital image data is usually recorded on a removable memory, such as a solid-state memory card or using internal memory.

3.2

DSC image signal

image data stored or output by a digital still camera

3.3
exposure index
EI

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

Note 1 to entry: Images obtained from a DSC using a range of exposure index values will normally provide a range of image quality levels.

3.4
exposure saturation

minimum focal plane exposure that produces the maximum valid (not clipped or bloomed) DSC image signal

Note 1 to entry: The exposure saturation is expressed in lux-seconds (lx·s).

3.5
exposure series

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

3.6
image sensor

electronic device that converts incident electromagnetic radiation into an electronic signal

EXAMPLE A charge coupled device (CCD) array or a CMOS image array.

3.7
ISO speed

numerical value calculated from the exposure provided at the focal plane of a DSC to produce specified DSC image signal characteristics

Note 1 to entry: 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.

3.8
ISO speed latitude

set of two numerical values calculated from the exposure provided at the focal plane of a DSC to produce specified DSC image signal characteristics

Note 1 to entry: The ISO speed latitude is expected to correlate with the range of exposure index values that provide acceptable image quality for normal scenes.

3.9
photographic sensitivity

general term used for numerical values calculated based on the exposure at the focal plane of a DSC which produces a specified DSC image signal level, such as the standard output sensitivity or recommended exposure index

Note 1 to entry: In practise, the photographic sensitivity is often called the "sensitivity" or the "camera sensitivity". It is sometimes called the "ISO sensitivity", for historical reasons that date from ISO standards for photographic film cameras.

3.10
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

3.11**recommended exposure index****REI**

specific exposure index value recommended by a DSC provider as a reference for adjusting photographic accessories

Note 1 to entry: 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.

3.12**signal processing**

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

3.13**sensitivity setting**

numerical value of the photographic sensitivity used by a DSC when capturing images

Note 1 to entry: In some cases the sensitivity setting is set by the user. In other cases it is set automatically by the DSC.

Note 2 to entry: In DSCs employing an automatic exposure control system, the difference between the EI value used to capture an image and the sensitivity setting is called the "exposure bias". The value of the exposure bias is typically indicated using EV (exposure value) units.

Note 3 to entry: For historical reasons, the sensitivity setting of a DSC is often labelled the "ISO".

3.14**standard output sensitivity****SOS**

specific exposure index value for a DSC that provides a still image with a specified DSC image signal value under specified test conditions

Note 1 to entry: 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**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 photographic sensitivity of a DSC is a particular EI value calculated from the exposure provided at the focal plane of the DSC that produces a specified camera image signal level.

The EI value I_{EI} for a specific image captured by a DSC shall be equal to the EI reference exposure of 10 lx·s divided by the focal plane exposure used to capture the image, as specified in [Formula \(1\)](#):

$$I_{EI} = K/H_m \quad (1)$$

where

K is a constant equal to 10 lx·s and

H_m is the average focal plane exposure, expressed in lx·s.

NOTE 1 For an average scene, the average focal plane exposure is a mid-tone exposure, which is approximately equal to the exposure which would be obtained from an 18 % reflectance test card positioned in the scene and illuminated by the main light source.

In the case where the image recorded by the camera is the result of processing that combines multiple captured images, the EI value corresponds to the sum of the exposures for the images that have been combined. In this case, the EI value should be reported along with a notation indicating that multiple images have been combined.

EI values should be reported using exposure index metadata in the image file header. In the case where multiple captured images have been combined, the number of captured images that were combined and the EI values for the individual captured images should also be reported using metadata.

4.2 Focal plane measurement

For DSCs where it is possible to measure the focal plane exposure directly, such as a DSC with a removable lens, the value of H_m should be measured using spatially uniform and spectrally neutral illumination. The measurement should be made within a circle lying in the centre of the focal plane with a diameter of 75/100 times the shorter dimension of the image field.

4.3 Estimating focal plane exposure from scene luminance

For DSCs where it is not practical to measure the focal plane exposure, the value of H_m required in [Formula \(1\)](#) should be estimated using [Formula \(2\)](#). The measurement should be made using a test card for a flat-field image (i.e. a spatially uniform field-of-view of spectrally neutral reflectance) at a distance of at least one meter, using only the portion of the field of view of the image sensor that is subtended by an angle of less than 10°. If the lens focus can be manually adjusted, it should be set to the infinity position. The derivation of [Formula \(2\)](#) is given in [Annex B](#).

$$H_m = \frac{65L_a t}{100A^2} \quad (2)$$

where

A is the f -number of the lens;

L_a is the luminance, expressed in candelas per square metre, measured using a full frame uniformly illuminated diffuse reflecting test card (i.e. a spatially uniform field-of-view of spectrally neutral reflectance);

t is the photosite integration time, expressed in seconds.

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 not appropriate to use 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 illumination approximating the ISO 7589 daylight or studio 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 studio tungsten illuminants. Also, the spectral power distribution of the illumination used should be reasonably similar to that of the ISO 7589 daylight or studio tungsten reference illuminant.

5.2.1 Daylight reference illuminant

For daylight measurements without the camera lens, the ISO sensitometric daylight illuminant given in ISO 7589:2002, Table 1, 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 ISO 7589:2002, Table 1. 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 reference illuminant

For tungsten measurements without the camera lens, the ISO sensitometric studio tungsten illuminant given in ISO 7589:2002, Table 2, 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 ISO 7589:2002, Table 2. 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 $(23 \pm 2) ^\circ\text{C}$ and the relative humidity should be $(50 \pm 20) \%$.

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. 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 and ISO speed latitude

6.1 General

With appropriate electrical or digital gain, a DSC can provide an appropriate DSC image signal level for a range of sensor exposure levels. The maximum exposure level is just below the exposure level where typical picture highlights will be clipped as a result of saturating the image sensor's signal capacity or reaching the camera signal processing's maximum signal level. The minimum exposure level relates to the amount of noise that can be tolerated in the image. These situations lead to two different types of speed value calculations: those based on saturation exposure, and those based on mid-tone noise characteristics. If the DSC provides an adequate dynamic range, the ISO speed is determined using a noise-based calculation and the saturation-based calculation is used to determine the camera's overexposure latitude. A second noise-based calculation is used to determine the camera's underexposure latitude.

For some types of DSCs, such as those employing lossy compression methods, it is not possible to correctly determine the mid-tone noise characteristics. In such cases, the ISO speed of the camera is determined using the saturation-based calculation, and the ISO speed latitude values are not reported. In other cases, the noise-based values may be lower than the saturation-based values, in which case the saturation based value is reported.

ISO speed and ISO speed latitude values may be reported for either scene-referred or output-referred images. ISO speed and ISO speed latitude values shall not be reported for raw images, however, because with raw images processing that affects the values has not been performed.

6.2 Saturation-based calculations

In photographic applications where the scene illumination level can be controlled, for example in studio photography, the photographer normally prefers to use an exposure index which provides the best possible image quality. In this situation, setting the exposure index based on the value determined using a saturation exposure based calculation is appropriate. This allows the user to set the camera exposure so that typical image highlights are just below the maximum possible (saturation) DSC image signal value.

6.2.1 Focal plane measurement

The saturation based value, I_{SAT} , of an electronic still picture camera is defined as:

$$I_{\text{sat}} = K_s / H_{\text{sat}} \quad (3)$$

where

K_s is a constant equal to 78 lx·s;

H_{SAT} is the exposure saturation level, expressed in lux-seconds (lx·s).

NOTE 1 The value of K_s in [Formula \(3\)](#) is larger than the value of K in [Formula \(1\)](#) because H_a in [Formula \(1\)](#) is a mid-tone exposure while H_{sat} is a highlight exposure.

NOTE 2 The value of K_s in [Formula \(3\)](#) provides 1/2 "stop" of headroom (41 % additional headroom) for specular highlights above the DSC image signal level that would be obtained from a theoretical 100 % reflectance object in the scene, such that a theoretical 141 % reflectance object in the scene would produce a focal plane exposure of H_{sat} .

The exposure saturation level shall be the lowest exposure level, such that less than 50 % of the pixels in a uniformly exposed region of interest (ROI) increase in digital value, when the exposure level is increased by an incremental step.

The incremental step shall increase the exposure level by no more than 26 % (0,333 step) and should increase the exposure level by no more than 10 % (0,137 step).

The ROI shall be 64×64 pixels, as defined in ISO 14524.

NOTE When the exposure levels are controlled by the DSC, it is preferable that the exposure level is mainly controlled by adjusting the shutter speed, while the f-number of the lens remains the same.

6.2.2 Scene luminance measurement

If the focal plane exposure of the DSC cannot be measured directly, it shall be estimated from the scene luminance measurement using [Formula \(2\)](#).

6.3 Noise-based calculations

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. However, using an excessively high exposure index can result in an unacceptably noisy image. Noise-based calculations use the mid-tone exposure that provides an appropriately low noise image for a typical DSC. The mid-tone exposure value $H_{S/N40}$ is based on an objective correlation to subjective judgements of the acceptability of various noise levels in exposure series images and provides the “first excellent” image. A lower mid-tone exposure value, $H_{S/N10}$, provides the “first acceptable” image, and is used to determine the ISO speed latitude upper limit.

6.3.1 Focal plane method

The two noise-based values of a DSC, $I_{S/N40}$ and $I_{S/N10}$, shall be determined from the focal plane exposure required to produce specific image incremental signal-to-noise (S/N) ratio values for a flat-field image, measured using linearized output signals from the DSC, using the following equations (see NOTE 1):

$$I_{S/N40} = K/H_{S/N40} \quad (4)$$

$$I_{S/N10} = K/H_{S/N10} \quad (5)$$

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

$$D = 40 \sigma(D) \quad (6)$$

K is a constant equal to $10 \text{ lx}\cdot\text{s}$, and $H_{S/N10}$ is the exposure that provides DSC image signals which, when linearized, satisfy [Formula \(7\)](#):

$$D = 10 \sigma(D) \quad (7)$$

where

- D is the linearized luminance signal level;
- H is the input exposure, in lux-seconds, needed to produce the linearized luminance signal level D ;
- $\sigma(D)$ 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 [6.3.3](#)), taken from a 64 by 64 pixel area (see NOTE 2).

The DSC image 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 $\sigma(D)$.

The value of H in [Formulae \(4\)](#) and [\(5\)](#) may be determined using the procedure described in [Annex A](#).

NOTE 1 The value of K that appears in the numerator of [Formulae \(4\)](#) and [\(5\)](#) places the exposures associated with the respective signal-to-noise ratios at a mid-tone exposure, which is approximately equal to the exposure that would be obtained from an 18 % reflectance value in a 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 document. 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 can still yield acceptably low noise prints, while for prints made using significantly lower sensor pixels per centimetre values, higher S/N values can 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.

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 [Formula \(2\)](#).

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 DSC image signals in many DSCs.

For colour cameras using a single exposure process, $\sigma(D)$ shall be determined using the linearized DSC image 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 image signals, the signals shall be decoded to provide RGB image signals using the inverse of the matrix used to encode the signals. The decoded RGB image signals shall then be converted to linearized RGB signals in accordance with ISO 14524.

If the DSC image 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 [Formula \(8\)](#):

$$Y = (2126/10\,000 R) + (7152/10\,000 G) + (722/10\,000 B) \quad (8)$$

The value of the camera noise, $\sigma(D)$ shall be computed using [Formula \(9\)](#):

$$\sigma(D) = \left\{ \sigma(Y)^2 + \left[279/1\,000 \sigma(R-Y)^2 \right] + \left[88/1\,000 \sigma(B-Y)^2 \right] \right\}^{1/2} \quad (9)$$

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 $\sigma(D)$ used in [Formulae \(6\)](#) and [\(7\)](#) 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 $I_{S/N40}$ is higher than I_{sat} , the reported number “xxx” shall be the value from the third column of [Table 1](#) from the same row as the $I_{S/N40}$ 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 I_{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 $I_{S/N10}$ value determined in [6.2](#).

If $I_{S/N40}$ is lower than I_{sat} , or if $I_{S/N40}$ 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 yyy”) for daylight illumination and “ISO yyy T” for tungsten illumination, where “yyy” is the speed rating from [Table 1](#) corresponding to the saturation based value determined in [6.2](#). The reported number “yyy” shall be the value from the third column of [Table 1](#) from the same row as the I_{sat} value (in the first column of [Table 1](#)) determined in [6.2](#). The ISO speed latitude shall be denoted as described in the preceding paragraph, unless the $I_{S/N10}$ value is lower than the I_{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.

The ISO speed reported in image file headers shall conform to the reporting requirements outlined above.

Table 1 — ISO speed and ISO speed latitude reported values

I_{sat} (from 6.2)	$I_{S/N}$ (from 6.3)	Reported value
$8 < I_{\text{sat}} < 10$	$10 < I_{S/N} < 12$	10
$10 < I_{\text{sat}} < 12$	$12 < I_{S/N} < 16$	12
$12 < I_{\text{sat}} < 16$	$16 < I_{S/N} < 20$	16
$16 < I_{\text{sat}} < 20$	$20 < I_{S/N} < 25$	20
$20 < I_{\text{sat}} < 25$	$25 < I_{S/N} < 32$	25
$25 < I_{\text{sat}} < 32$	$32 < I_{S/N} < 40$	32
$32 < I_{\text{sat}} < 40$	$40 < I_{S/N} < 50$	40
$40 < I_{\text{sat}} < 50$	$50 < I_{S/N} < 64$	50
$50 < I_{\text{sat}} < 64$	$64 < I_{S/N} < 80$	64
$64 < I_{\text{sat}} < 80$	$80 < I_{S/N} < 100$	80
$80 < I_{\text{sat}} < 100$	$100 < I_{S/N} < 125$	100
$100 < I_{\text{sat}} < 125$	$125 < I_{S/N} < 160$	125
$125 < I_{\text{sat}} < 160$	$160 < I_{S/N} < 200$	160
$160 < I_{\text{sat}} < 200$	$200 < I_{S/N} < 250$	200
$200 < I_{\text{sat}} < 250$	$250 < I_{S/N} < 320$	250
$250 < I_{\text{sat}} < 320$	$320 < I_{S/N} < 400$	320
$320 < I_{\text{sat}} < 400$	$400 < I_{S/N} < 500$	400
$400 < I_{\text{sat}} < 500$	$500 < I_{S/N} < 640$	500

Table 1 (continued)

I_{sat} (from 6.2)	$I_{\text{S/N}}$ (from 6.3)	Reported value
$500 < I_{\text{sat}} < 640$	$640 < I_{\text{S/N}} < 800$	640
$640 < I_{\text{sat}} < 800$	$800 < I_{\text{S/N}} < 1\,000$	800
$800 < I_{\text{sat}} < 1\,000$	$1\,000 < I_{\text{S/N}} < 1\,250$	1 000
$1\,000 < I_{\text{sat}} < 1\,250$	$1\,250 < I_{\text{S/N}} < 1\,600$	1 250
$1\,250 < I_{\text{sat}} < 1\,600$	$1\,600 < I_{\text{S/N}} < 2\,000$	1 600
$1\,600 < I_{\text{sat}} < 2\,000$	$2\,000 < I_{\text{S/N}} < 2\,500$	2 000
$2\,000 < I_{\text{sat}} < 2\,500$	$2\,500 < I_{\text{S/N}} < 3\,200$	2 500
$2\,500 < I_{\text{sat}} < 3\,200$	$3\,200 < I_{\text{S/N}} < 4\,000$	3 200
$3\,200 < I_{\text{sat}} < 4\,000$	$4\,000 < I_{\text{S/N}} < 5\,000$	4 000
$4\,000 < I_{\text{sat}} < 5\,000$	$5\,000 < I_{\text{S/N}} < 6\,400$	5 000
$5\,000 < I_{\text{sat}} < 6\,400$	$6\,400 < I_{\text{S/N}} < 8\,000$	6 400
$6\,400 < I_{\text{sat}} < 8\,000$	$8\,000 < I_{\text{S/N}} < 10\,000$	8 000
$8\,000 < I_{\text{sat}} < 10\,000$	$10\,000 < I_{\text{S/N}} < 12\,500$	10 000
$10\,000 < I_{\text{sat}} < 12\,500$	$12\,500 < I_{\text{S/N}} < 16\,000$	12 500
$12\,500 < I_{\text{sat}} < 16\,000$	$16\,000 < I_{\text{S/N}} < 20\,000$	16 000
$16\,000 < I_{\text{sat}} < 20\,000$	$20\,000 < I_{\text{S/N}} < 25\,000$	20 000
$20\,000 < I_{\text{sat}} < 25\,000$	$25\,000 < I_{\text{S/N}} < 32\,000$	25 000
$25\,000 < I_{\text{sat}} < 32\,000$	$32\,000 < I_{\text{S/N}} < 40\,000$	32 000
$32\,000 < I_{\text{sat}} < 40\,000$	$40\,000 < I_{\text{S/N}} < 50\,000$	40 000
$40\,000 < I_{\text{sat}} < 50\,000$	$50\,000 < I_{\text{S/N}} < 64\,000$	50 000
$50\,000 < I_{\text{sat}} < 64\,000$	$64\,000 < I_{\text{S/N}} < 80\,000$	64 000
$64\,000 < I_{\text{sat}} < 80\,000$	$80\,000 < I_{\text{S/N}} < 100\,000$	80 000
$80\,000 < I_{\text{sat}} < 100\,000$	$100\,000 < I_{\text{S/N}} < 125\,000$	100 000
$100\,000 < I_{\text{sat}} < 125\,000$	$125\,000 < I_{\text{S/N}} < 160\,000$	125 000
$125\,000 < I_{\text{sat}} < 160\,000$	$160\,000 < I_{\text{S/N}} < 200\,000$	160 000
$160\,000 < I_{\text{sat}} < 200\,000$	$200\,000 < I_{\text{S/N}} < 250\,000$	200 000
$200\,000 < I_{\text{sat}} < 250\,000$	$250\,000 < I_{\text{S/N}} < 320\,000$	250 000
$250\,000 < I_{\text{sat}} < 320\,000$	$320\,000 < I_{\text{S/N}} < 400\,000$	320 000
$320\,000 < I_{\text{sat}} < 400\,000$	$400\,000 < I_{\text{S/N}} < 500\,000$	400 000
$400\,000 < I_{\text{sat}} < 500\,000$	$500\,000 < I_{\text{S/N}} < 640\,000$	500 000
$500\,000 < I_{\text{sat}} < 640\,000$	$640\,000 < I_{\text{S/N}} < 800\,000$	640 000
$640\,000 < I_{\text{sat}} < 800\,000$	$800\,000 < I_{\text{S/N}} < 1\,000\,000$	800 000
$800\,000 < I_{\text{sat}} < 1\,000\,000$	$1\,000\,000 < I_{\text{S/N}} < 1\,250\,000$	1 000 000
$1\,000\,000 < I_{\text{sat}} < 1\,250\,000$	$1\,250\,000 < I_{\text{S/N}} < 1\,600\,000$	1 250 000
$1\,250\,000 < I_{\text{sat}} < 1\,600\,000$	$1\,600\,000 < I_{\text{S/N}} < 2\,000\,000$	1 600 000
$1\,600\,000 < I_{\text{sat}} < 2\,000\,000$	$2\,000\,000 < I_{\text{S/N}} < 2\,500\,000$	2 000 000
$2\,000\,000 < I_{\text{sat}} < 2\,500\,000$	$2\,500\,000 < I_{\text{S/N}} < 3\,200\,000$	2 500 000
$2\,500\,000 < I_{\text{sat}} < 3\,200\,000$	$3\,200\,000 < I_{\text{S/N}} < 4\,000\,000$	3 200 000
$3\,200\,000 < I_{\text{sat}} < 4\,000\,000$	$4\,000\,000 < I_{\text{S/N}} < 5\,000\,000$	4 000 000
$4\,000\,000 < I_{\text{sat}} < 5\,000\,000$	$5\,000\,000 < I_{\text{S/N}} < 6\,400\,000$	5 000 000

Table 1 (continued)

I_{sat} (from 6.2)	$I_{\text{S/N}}$ (from 6.3)	Reported value
$5\,000\,000 < I_{\text{sat}} < 6\,400\,000$	$6\,400\,000 < I_{\text{S/N}} < 8\,000\,000$	6 400 000
$6\,400\,000 < I_{\text{sat}} < 8\,000\,000$	$8\,000\,000 < I_{\text{S/N}} < 10\,000\,000$	8 000 000
$8\,000\,000 < I_{\text{sat}} < 10\,000\,000$	$10\,000\,000 < I_{\text{S/N}} < 12\,500\,000$	10 000 000

NOTE Rounding of EI values is not specified.

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 DSC image signal value under specified test conditions.

Since the SOS value varies along with the DSC ISO sensitivity setting, the SOS should be determined for a fixed sensitivity setting. When the DSC uses an automatic variable sensitivity mode, the SOS may be reported as “variable”, or the range of the SOS values may be reported. Furthermore, the image rendering processing applied in some DSCs can be scene-dependent and can result in a variable SOS even when the DSC is set on a fixed sensitivity. When this is the case, the SOS may be reported as “variable” or the range of the SOS values may be reported. Changing the colour encoding output by the DSC can also change the SOS. It is generally not appropriate to report SOS values for raw files, since the SOS value will depend on the subsequent processing of the files.

Regardless of the sensitivity mode of the DSC, the SOS value applicable when the image is captured may be reported as the SOS value accompanying the recorded image, which can be attached as metadata in the recorded image file.

7.1 Method for calculating SOS

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

$$I_{\text{SOS}} = K / H_{\text{SOS}} \quad (10)$$

where

K is a constant equal to 10 lx·s and

H_{SOS} is the exposure required to produce the specified standard level DSC image signal equal to $461/1\,000 \times O_{\text{MAX}}$ (11)

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

NOTE The code value of 118 in an 8-bit system corresponds to 18 % of the maximum final output for sRGB.

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/m² 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 [Formula \(10\)](#) shall be rounded off using [Table 2](#) 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)

where “sss” is the reported value from the second column in [Table 2](#).

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)

8.1 General

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 is not useful and should not be reported.

8.2 Method for calculating recommended exposure index

The DSC recommended exposure index shall be computed using the following [Formula \(12\)](#):

$$I_{REI} = K/H_m \quad (12)$$

where

K is a constant equal to 10 lx·s;

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.

The I_{REI} should be reported for both daylight and tungsten illumination.

8.3 Method of reporting

The value calculated using [Formula \(12\)](#) shall be rounded off using [Table 2](#) 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)

where “rrr” is the reported value from the second column in [Table 2](#).

Table 2 — I_{SOS} and I_{REI} reported values

x is the measured value of I_{SOS} and I_{REI}	Reported value
8,909 < x < 11,22	10
11,22 < x < 14,14	12
14,14 < x < 17,82	16
17,82 < x < 22,45	20
22,45 < x < 28,28	25
28,28 < x < 35,64	32
35,64 < x < 44,90	40
44,90 < x < 56,57	50
56,57 < x < 71,27	64
71,27 < x < 89,09	80
89,09 < x < 112,2	100
112,2 < x < 141,4	125
141,4 < x < 178,2	160
178,2 < x < 224,5	200
224,5 < x < 282,8	250
282,8 < x < 356,4	320
356,4 < x < 449,0	400
449,0 < x < 565,7	500
565,7 < x < 712,7	640
712,7 < x < 890,9	800
890,9 < x < 1 122	1 000
1 122 < x < 1 414	1 250
1 414 < x < 1 782	1 600
1 782 < x < 2 245	2 000
2 245 < x < 2 828	2 500
2 828 < x < 3 564	3 200
3 564 < x < 4 490	4 000
4 490 < x < 5 657	5 000
5 657 < x < 7 127	6 400
7 127 < x < 8 909	8 000
9 090 < x < 11 220	10 000
11 220 < x < 14 140	12 500 or 12 800
14 140 < x < 17 820	16 000
17 820 < x < 22 450	20 000
22 450 < x < 28 280	25 000 or 25 600
28 280 < x < 35 640	32 000
35 640 < x < 44 900	40 000
44 900 < x < 56 570	50 000 or 51 200
56 570 < x < 71 270	64 000
71 270 < x < 89 090	80 000
89 090 < x < 112 200	100 000 or 102 400
112 200 < x < 141 400	125 000 or 128 000
141 400 < x < 178 200	160 000

Table 2 (continued)

x is the measured value of I_{SOS} and I_{REI}	Reported value
178 200 < x < 224 500	200 000 or 204 800
224 500 < x < 282 800	250 000 or 256 000
282 800 < x < 356 400	320 000
356 400 < x < 449 000	400 000 or 409 600
449 000 < x < 565 700	500 000 or 512 000
565 700 < x < 712 700	640 000
712 700 < x < 890 900	800 000 or 819 200
890 900 < x < 1 122 000	1 000 000 or 1 024 000
1 122 000 < x < 1 414 000	1 250 000 or 1 280 000
1 414 000 < x < 1 782 000	1 600 000
1 782 000 < x < 2 245 000	2 000 000 or 2 048 000
2 245 000 < x < 2 828 000	2 500 000 or 2 560 000
2 828 000 < x < 3 564 000	3 200 000
3 564 000 < x < 4 490 000	4 000 000 or 4 096 000
4 490 000 < x < 5 657 000	5 000 000 or 5 120 000
5 657 000 < x < 7 127 000	6 400 000
7 127 000 < x < 8 909 000	8 000 000 or 8 192 000
8 909 000 < x < 11 220 000	10 000 000 or 10 240 000

Annex A (informative)

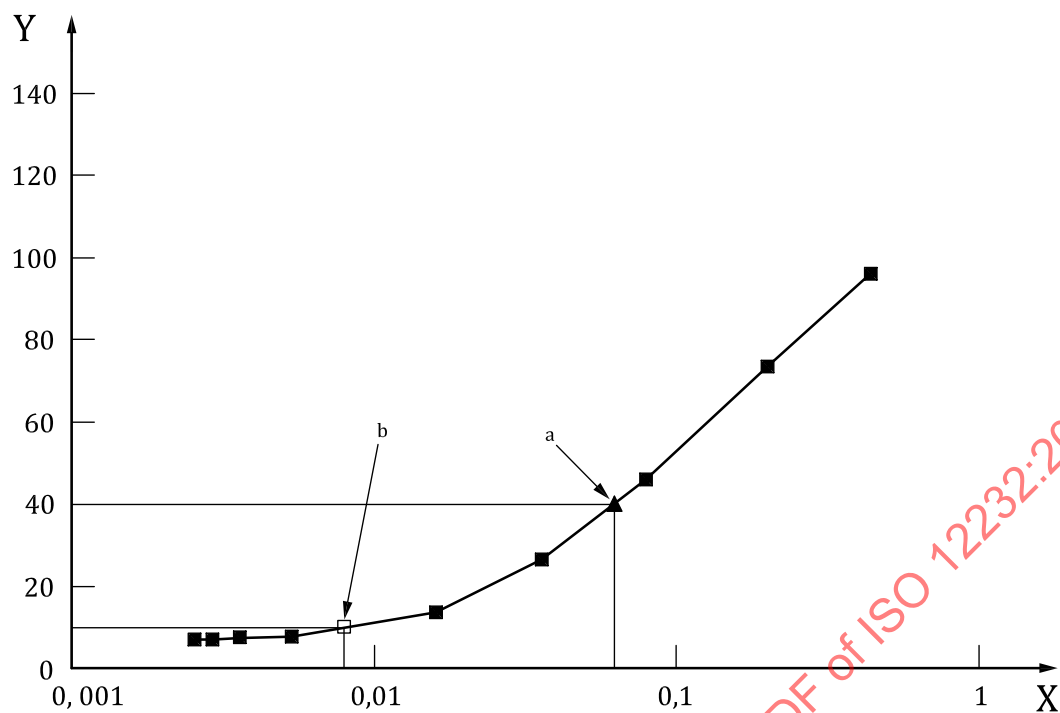
Recommended procedure for determining the noise-based ISO speed

The value of H in [Formulae \(4\)](#) or [\(5\)](#) 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 $I_{S/N40}$ and 10 for $I_{S/N10}$.

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 RGB DSC image signals into linearized RGB signals.
- c) Calculate linearized Y , $R-Y$, and $B-Y$ image data using [Formula \(8\)](#) to calculate Y . 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 [Formula \(9\)](#).
- 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 [Formulae \(4\)](#) and [\(5\)](#) to determine the ISO noise-based speeds. Use [Table 1](#) to determine the reported value.

[Figure A.1](#) shows an example of a logarithmic 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.



- Key**
- X exposure H , lx·s
- Y signal-to-noise ratio, CSNR
- a At CSNR = 40, $H = (68/1\ 000)$ lx·s, corresponding to an ISO speed reported value of 125.
- b At CSNR = 10, $H = (8/1\ 000)$ lx·s, corresponding to an ISO speed latitude upper limit reported value of 1 250.

NOTE In accordance with ISO 31-0, the decimal sign is a comma.

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