INTERNATIONAL STANDARD

ISO 19093

First edition
2018-08

Photography — Digital cameras — Measuring low-light performance

Photographie — Caméras numériques — Mesurage des performances dans des conditions de faible luminosité

Reference number
ISO 19093:2018(E)

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 Test conditions and setup **2**
4.1 Test chart 2
4.1.1 Test chart and illumination 2
4.2 Camera settings 3
4.2.1 General 3
4.2.2 Test lenses 4
4.2.3 Auto focus 4
4.2.4 Quality and file type 4
4.2.5 ISO sensitivity setting 4
4.2.6 White balance 4
4.2.7 Flash 5
4.2.8 Noise reduction 5
4.2.9 Exposure mode 5
4.2.10 Scene and capture modes 5
4.3 Capturing a reference image 5
4.4 Capture of the test images 5
4.4.1 Illumination level 5
4.4.2 Best image selection 5
5 Camera performance aspects affected by low light **6**
5.1 Exposure time 6
5.2 Exposure level 6
5.3 Noise 6
5.4 Texture (low-contrast fine detail) 6
5.5 Chroma decrease 7
6 Presentation of the results **8**
Annex A (informative) **Example for generating a single performance value from measured results** **10**
Annex B (normative) **Test chart** **12**
Bibliography **19**

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 of 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 www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The major engineering difference between a system camera, a point and shoot camera, and a camera in a mobile device is the sensor size. The sensor size is also related to the overall system size including the lens. With smaller sensors, the individual light sensitive areas are also smaller and therefore less light falls onto each of the pixels.

Smaller individual light sensitive areas require higher signal amplification that leads to higher noise levels or other problems that can occur due to denoising algorithms. These problems become more visible at low-light conditions because of the lower signal levels.

Most cameras are used without a tripod even at low-light conditions. At low light in combination with a tripod, the performance of a camera is always good because the sensitivity setting can be kept to a low value and the exposure time can be very long. For these reasons the low-light performance is measured using conditions that reflect the result of a handheld shot.

Sometimes the data sheets of a camera state a light level for the low-light performance of a camera. Prior to the creation of this document, the way to determine these values was not defined and therefore the values were unreliable to users.

Photography — Digital cameras — Measuring low-light performance

1 Scope

This document specifies a protocol to measure the low-light performance of a camera. It is applicable to the measurement of digital cameras including camera phones and other mobile devices.

The performance aspects defined in this document are intended to all be tested. Picking one or some of them by the tester is out of scope of the usage of this document.

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, *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)*

ISO 15739, *Photography — Electronic still-picture imaging — Noise measurements*

ISO/TS 19567-1, *Photography — Digital cameras — Texture reproduction measurements — Part 1: Frequency characteristics measurements using cyclic pattern*

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

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
handheld limit exposure time
exposure time empirically considered as an upper limit to give a reasonably sharp image with handheld shooting, which is 1/*f* s, where *f* is the value of the 35 mm sensor equivalent focal length of the lens

Note 1 to entry: If the camera has a mechanism for image stabilization, a longer exposure time than 1/*f* s for handheld shooting can still produce reasonably sharp images.

3.2
35 mm film equivalent focal length
focal length of a lens attached to a camera with a sensor size of 24 mm × 36 mm (originated from 35 mm film) that produces the same field of view as the camera system with a lens at a given focal length for which the 35 mm sensor equivalent focal length is specified

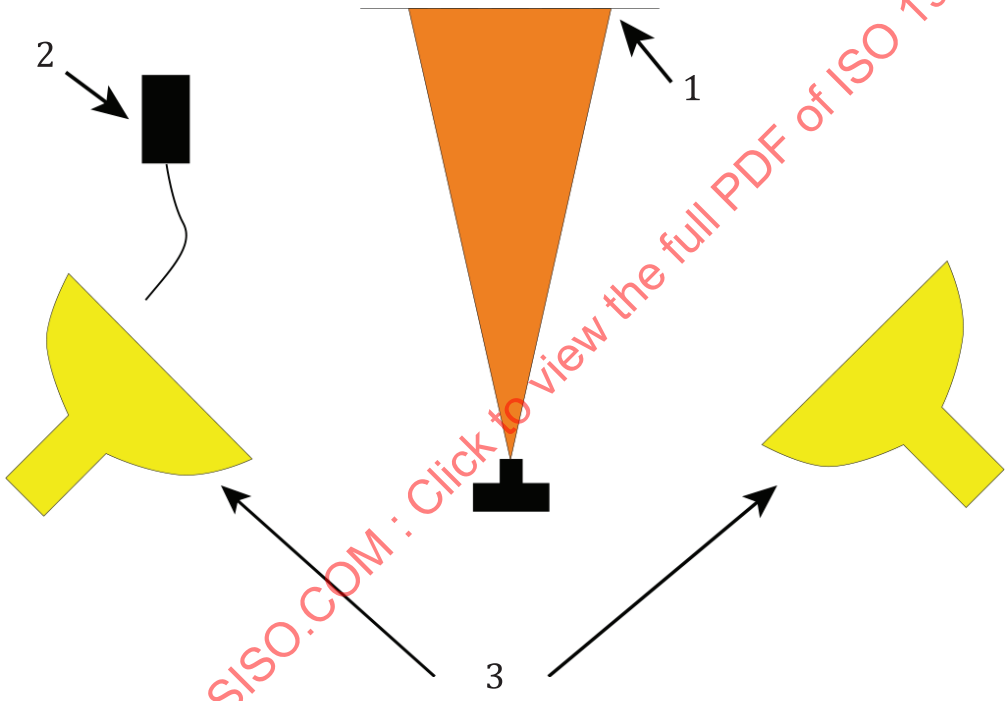
3.3
full frame sensor
image sensor that fills the full 24 mm × 36 mm image size of the 35 mm film format

4 Test conditions and setup

4.1 Test chart

4.1.1 Test chart and illumination

The lighting condition shall be consistent with the daylight conditions specified in ISO 7589. The chart shall be uniformly illuminated in a way that minimizes stray light and specular reflection. The light source needs to be dimmable without a significant change in the spectral distribution of the light. Using a set of polarizing filters, neutral density filters or using a special spectrally tunable LED light source can achieve this. See Figure 1.



Key
1 test chart
2 spectroradiometer
3 dimmable daylight source

Figure 1 — Setup of the chart illumination

Since modern still cameras provide scene-dependent image processing, the ideal approach for a low-light test is using a test chart that contains all necessary structures for evaluating the relevant image-quality parameters. The following chart is one commercially available example for such a chart.

The chart shall contain at least the following structures:

— a grey scale according to ISO 14524 with a contrast range of at least 100:1 and at least 16 grey levels to determine the opto-electronic conversion function (OECF) and noise performance according to ISO 14524 and ISO 15739;

— a set of colour patches with at least 18 colours including colours similar to the ones mentioned in ISO 17321-1 for colour characterization. The height and width of each patch shall be greater than 2 % of the image height;

— sinusoidal resolution structures in low contrast to determine the texture MTF according to ISO TS 19567-1;

— a focusing aid feature consisting of concentric black and white circles at different frequencies shall be placed in the centre of the chart as shown in Figure 2;

— an area of 18 % grey shall be included, and shall additionally form the background on which the other chart features are placed.

Even though the current version of this document does not use them, it can be helpful to include the following optional structures:

— coloured dead leaves structures for additional texture analysis on stochastic structures as described in ISO TS 19567-2;

— resolution structures according to ISO 12233 to determine the modulation transfer function (MTF).

The minimum active chart height shall be 675 mm, which is approximately 30 times the height of a 35 mm film equivalent "full frame" sensor. See Annex B for a detailed description of the chart.

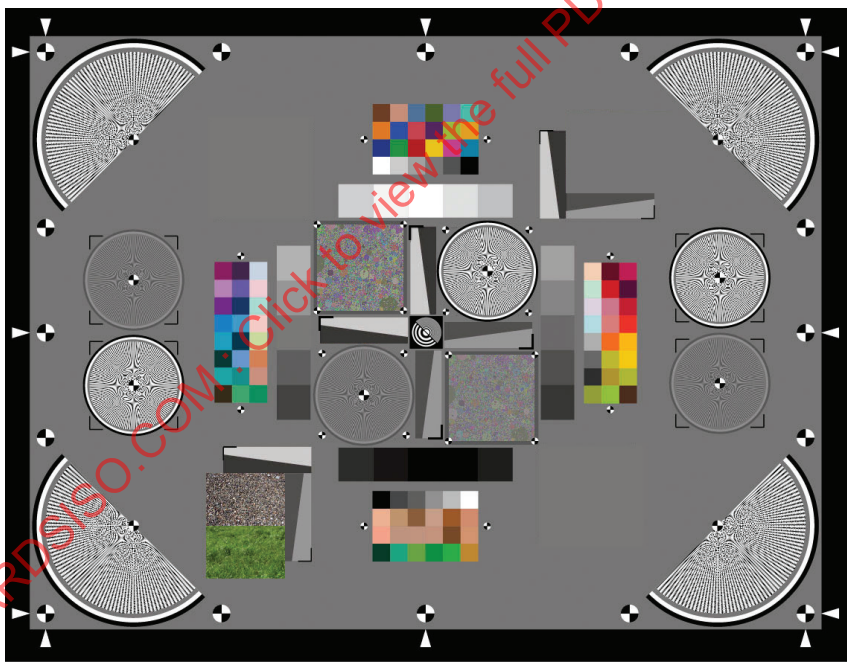


Figure 2 — An example for the multi-purpose test chart

4.2 Camera settings

4.2.1 General

The camera shall be fixed on a test bench during all the tests. The test needs to produce comparable results over a huge variety of different cameras. The biggest challenge is to provide a fair comparison between cameras with no control elements for the image capture (like exposure, ISO sensitivity, etc.) and cameras that require or at least allow full control over all functions and features.

4.2.2 Test lenses

For low-light performance comparison of cameras with interchangeable lenses, lenses with the same open aperture and 35 mm film equivalent focal length shall be used.

All cameras shall be tested at 28 mm focal length (35 mm sensor equivalent) if available. The reason for using the same equivalent focal length is to get comparable results for all cameras. In case of fixed focal length most cameras consist of a slight wide angle lens with an equivalent focal length around 28 mm, which is the reason why this focal length is to be the default. Open aperture shall be used for all measurements.

4.2.3 Auto focus

All images should be captured using the auto focus (AF) function. In case a camera does not have an AF, it shall be reported together with the results.

When a test camera has an AF function, refocusing is required for every capture. An object may be put between the test chart and the camera to trigger the refocusing. The auto focus mode of the camera can have an impact on the results and shall therefore be reported together with the results.

When a tested camera fails to focus at some light levels, a column should be added to the result table indicating at which light levels this was the case. The camera's focus indicator, if available, may be used to identify a focus failure. Focus failure may be determined by visually examining the image for noticeable poor focus.

If a camera with an AF function is tested in manual focus mode, the tester shall verify that the AF function works under all lighting conditions. The verification needs to be mentioned together with the results.

4.2.4 Quality and file type

In case the purpose of the use of this document is to compare the raw images of different cameras, the raw images shall be captured and ideally be processed using the same raw processing software with identical settings. If no raw processing software that can process all images is available, then multiple processors should be configured to use comparable settings and produce comparable results. The raw processing software used and the fact that the comparison is based on raw images shall be explicitly mentioned together with the results.

In all other cases, the compared images are output-referred images that were processed in the camera. In these cases, cameras should be set to produce the highest image quality (lowest compression). This is typically a mode that creates a final TIFF or JPEG file.

4.2.5 ISO sensitivity setting

If available, the "auto ISO sensitivity" feature for automatic scene dependent signal amplification shall be used. If available, the handheld limit exposure time shall be selected as the longest exposure time (see 5.1).

In case this feature is not available, then for each illumination level, the ISO sensitivity value shall be set as follows:

a) Determine the handheld limit exposure time.

b) Set ISO sensitivity value such that exposure time shall not exceed the handheld limit exposure time.

4.2.6 White balance

The white balance shall be set to automatic.

4.2.7 Flash

No flash or camera built-in light sources shall be used or switched on. For cameras where these cannot be switched off, this test is generally not applicable. In some cases, it can be possible to cover the built-in light sources and perform the test.

4.2.8 Noise reduction

The noise reduction shall be set to the default level.

4.2.9 Exposure mode

Where available, the camera shall be set to auto-program mode. The exposure shall be determined and set by the camera without any exposure compensation.

4.2.10 Scene and capture modes

The balancing of the different image quality/image processing parameters in a camera can vary with a specific scene mode (low-light mode, portrait mode, landscape mode, etc.) or capture mode (high dynamic range (HDR), noise reduction mode, etc.). In case this document is used to compare the modes of a camera or to compare cameras set to a specific mode, the modes need to be mentioned together with the results.

4.3 Capturing a reference image

For the low-light performance, some measurements need to be defined relative to the performance under bright light conditions. In order to do this, a reference image needs to be captured at a relatively high illumination level on the chart plane. An image captured at an illumination level that should be ≥1 000 lx and shall be >500 lx is used to determine all required reference image quality levels.

NOTE Chroma decrease is evaluated relative to the reference image, and these relative evaluation metrics are based on the assumption that respective reference images are similar. Deviations among the reference images will lead to wrong evaluations.

4.4 Capture of the test images

4.4.1 Illumination level

Above a chart illumination level of 100 lx, most cameras deliver acceptable images. After taking the reference image, the illumination can be reduced to 100 lx as the starting point for the test images and then be reduced in steps further down. Tests shall be performed with multiple illumination levels. A suggestion for the steps is to use illumination levels of 50 lx, 25 lx 12,5 lx, 6 lx, 3 lx, 1,5 lx, 0,75 lx, 0,38 lx, 0,19 lx, etc.

The test range of illumination level shall be predetermined to measure low-light performance with all the camera performance aspects described in Clause 5. For example, even when the exposure time reaches the handheld limit exposure time, the illumination level may be further reduced to measure other performance aspects within the predetermined range.

4.4.2 Best image selection

A series of at least four images shall be captured at each light level and the image with the highest limiting resolution (frequency at 10 % modulation) in the centre shall be used for evaluation.

For the selected best image at each light level, all of the mentioned image quality criteria need to be evaluated and reported in a table as described in the reporting of the results (see Clause 6).

5 Camera performance aspects affected by low light

5.1 Exposure time

In order not to lose detail, the exposure time needs to be short enough to prevent the image from getting blurred due to human handshake. Therefore, the exposure time needs to be monitored and reported.

In case the camera has a mechanism for image stabilization (IS), a longer exposure time than the handheld limit exposure time can still produce reasonably sharp images. In this case, image stabilization performance according to CIPA DC-011[5] (number of stops) shall be reported together with the results.

The "longer exposure time" to be tested for systems with an image stabilization that is not purely optical shall be the handheld limit exposure time until a suitable method is published in ISO 20954-2.

NOTE In case non-optical image stabilization technologies such as the combination of multiple images to a single one are used, this needs to be reported together with the results. In this case, the effective exposure time is the sum of the individual exposure times unless a new definition is published in ISO 20954-2 and a method for these systems is defined on how many *f*-stops are gained with the method.

5.2 Exposure level

A way to hide the noise in the image or to prevent blur due to camera shake is to intentionally underexpose the images. That way, the bright parts will be visible but high noise levels can be hidden in the dark areas. Underexposed images look too dark and are therefore undesirable.

The 18 % grey background of the test chart is typically reproduced as an L^*50 value in the output image colour encoding. In case of an 8-bit sRGB image (see IEC 61966-2-1) the aim value is a digital output value of 118.

Due to potential shading of the optical system, the grey value shall be measured at the 18 % grey area that is closest to the centre of the image.

5.3 Noise

If the raw signal is amplified without any noise reduction, then the result will be a noisy image. Below a certain light level, the noise will obscure the signal in a way that renders the image unacceptable.

For the evaluation of noise, the visual noise shall be measured according to ISO 15739 as a mean value over the grey scale in the test chart excluding patches with L^* values above 80 and below 20 (densities above 1,5 and below 0,25). The applied contrast sensitivity function shall be the one for viewing the images with pixel density 150 µm per pixel from a 500 mm distance. At this resolution and distance, the pixels subtend about 1' (1/60°), which is approximately the limit of the human visual system. (This viewing condition is also equivalent to a 100 % viewing of images on a 4k 76 cm (30" class) display from a 500 mm distance). The actual image size in this case depends on the pixel count of the image. Should a manufacturer decide to down sample an image (e.g. in low-light mode of a camera) to average noise over multiple pixels, this would result in a lower pixel count. Therefore it is necessary to report the pixel count together with the result.

5.4 Texture (low-contrast fine detail)

The resolution structures described in ISO 12233[1] are structures with a relatively high contrast level. A sophisticated noise reduction algorithm detects high-contrast structures and therefore should not affect resolution structures in a significant way. These algorithms however can affect low-contrast fine detail.

ISO TS 19567-1 describes how to measure the MTF on texture. The frequency for the 10 % modulation shall be reported as a function of the illumination level.

NOTE Texture reproduction and resolution measurement are very similar. During the creation of this document, it was found that the loss of texture was always more significant. Therefore, the measurement of resolution is possible but not necessary for the determination of low-light performance.

5.5 Chroma decrease

A smoothing algorithm in the colour channels can lead to desaturated colours.

Cameras can introduce deliberate colour casts at low-light levels, to cater to human preference for warmer colour temperatures in low-light images. This document does not aim to penalize this behaviour. However, loss of chroma is undesirable and so this document includes the measurement of colour desaturation at low-light levels.

For the analysis of colour patches in the image of the target, a region of interest (ROI) shall be drawn over the colour patch and based on all pixels in the ROI. The mean chroma value shall be calculated for each patch relative to the white reference patch. The white patch in the lower left corner (E5) of the centred upper colour patches shall be used as a white reference patch in CIELAB calculation to compensate for colour casts left in the image at low-light levels. To determine the chroma values, the RGB values need to be converted into CIE XYZ coordinates based on the colour encoding of the image. These CIE XYZ values are then converted into CIE a* and b* values as given in Formulae (1) and (2). In case there is no information about the colour encoding in the metadata of the image, an sRGB encoding according to IEC 61966-2-1 shall be assumed.

For X/X_n, Y/Y_n and $Z/Z_n > 0{,}008\,856$

$$a^* = 500\left[\sqrt[3]{\left(\frac{X}{X_n}\right)} - \sqrt[3]{\left(\frac{Y}{Y_n}\right)}\right] \tag{1}$$

$$b^* = 200\left[\sqrt[3]{\left(\frac{Y}{Y_n}\right)} - \sqrt[3]{\left(\frac{Z}{Z_n}\right)}\right] \tag{2}$$

with n being the value of the white reference patch in the individual image.

If X/X_n, Y/Y_n or $Z/Z_n \leq 0{,}008\,856$ the respective ratios are substituted by

$7{,}787 \cdot (X/X_n) + 0{,}138$

$7{,}787 \cdot (Y/Y_n) + 0{,}138$

$7{,}787 \cdot (Z/Z_n) + 0{,}138$

The chroma value is calculated from Formulae (3) and (4):

$$C^* = \sqrt{\left(a^*\right)^2 + \left(b^*\right)^2} \tag{3}$$

The chroma decrease shall be calculated as the mean chroma ratio of the 18 colour patches (Patches E2 – E4, F2 – F4, G2 – G4, H2 – H4, I2 – I4, J2 – J4, as described in Annex B) in the centred upper part of the test image and the same colour patches in the reference image.

$$C_{\text{decrease}} = \frac{1}{18}\sum_{i=1}^{18}\frac{\overline{C^*_{\text{test}\ i}}}{\overline{C^*_{\text{reference}\ i}}} \tag{4}$$

with

$\overline{C^*}_{\text{test}}$ being the mean value for each colour patch from the test image at the specific light level;

$\overline{C^*}_{\text{reference}}$ being the mean value for each colour patch from the image taken at the reference light level;

i being the individual colour patch.

6 Presentation of the results

All the performance aspects in Clause 5 shall be tested and reported.

All the camera settings specified in 4.2 shall be mentioned together with the results. If the image has been down sampled from the default maximum output pixel count to reduce noise, the image pixel count shall also be mentioned together with the results.

The results shall be presented in the form of two tables as shown in Tables 1 and 2. This enables the user of this document to select the important image quality aspects for specific applications by using selected tolerance levels for each image quality aspect.

In case the user of this document intends to report a single light level as the low-light performance value of a camera, Annex A provides guidance on how this can be done.

Table 1 — Results table of an example camera

Light level	Exposure time[a]	Exposure level	Noise	Texture	$C_{decrease}$
1 000 lx reference	0,008 0	127	1	1 450	1
100 lx	0,016 7	127	1,5	1 300	1
50 lx	0,016 7	127	2	1 270	1
25 lx	0,016 7	127	2,3	1 120	1
12,5 lx	0,016 7	125	3	1 085	1
6 lx	0,016 7	120	4	988	0,8
3 lx	0,016 7	115	5	922	0,5
1,5 lx	0,016 7	110	7	900	0,4
0,75 lx	0,033 3	95	8	756	0,3
0,38 lx	0,066 7	80	10	678	0,2
0,19 lx	0,125 0	70	12	599	0,2

Camera XXX in program mode with auto sensitivity.

Output pixel count of 4 000 px × 3 000 px. Standard AF was used.

[a] handheld limit exposure time is 1/28 s = 0,035 7 s (this camera has 4,0-stop image stabilization according to CIPA DC-011[5]).

Table 2 — Additional table with ISO and aperture values

Light level	ISO	*f*-number
1 000 lx reference	100	4
100 lx	100	2,8
50 lx	200	2,8
25 lx	400	2,8
12,5 lx	800	2,8
6 lx	1 600	2,8
3 lx	3 200	2,8
1,5 lx	3 200	2,8
0,75 lx	3 200	2,8
0,38 lx	3 200	2,8
0,19 lx	3 200	2,8

Aspects that need to be reported in detail in case of deviation from the settings specified in 4.2 such as:

— longer focal length than 28 mm (35 mm sensor equivalent);

— lens description for cameras with interchangeable lenses (including mount converters and any other optical accessories;

— manual focus if AF is not available or if manual focus has been used after verifying that AF works under all lighting conditions;

— image stabilization used (including the use of multiple images) and test results for image stabilization (see 5.1);

— scene modes such as low-light, portrait, landscape, sport, etc.;

— capture modes such as high dynamic range (HDR), noise reduction, local tone mapping;

— use of raw images together with the raw-converter.

Annex A
(informative)

Example for generating a single performance value from measured results

A.1 General

A way to report a single number that describes the low-light performance of a camera is to select the light level for which all values measured as described in Clause 5 are within certain tolerance levels.

The test procedure described in this document is not designed to judge the overall image quality at any light level. Aspects such as the resolution of the system are system dependent. Therefore, absolute resolution or colour reproduction levels cannot be used to define tolerances in order to create a single performance value. For the low-light performance, some measurements need to be defined relative to the performance under bright light conditions.

To increase the precision of the exact illumination levels where tolerances are reached, narrower steps around the important levels should be used.

The following set of tolerance levels is a sample set of tolerances based on the evaluation of an experiment with 25 cameras done by a group of experts and on some tolerances defined in IEC 61146-1[3]. In case a single low-light performance value is used, a set of tolerances needs to be specified for the determination of that single number. Table A.1 shows an example for a potential result table using threshold values.

A.2 Exposure time

Most images are captured without a tripod or any other support for the camera to rest on during exposure. In order not to lose detail, the exposure time therefore needs to be short enough to prevent the image from getting blurred due to human handshake.

Without image stabilization at a focal length of 28 mm (35 mm film equivalent), an exposure time longer than 1/20 of a second will usually lead to blurring. Therefore, the exposure time needs to be shorter than or equal to 1/20 of a second. The 1/20 of a second can also be used if the focal length used is shorter than 28 mm. In case the focal length used is longer than 28 mm (35 mm film equivalent), the rule of thumb can be applied that the handheld limit exposure time used is shorter than or equal to the reciprocal of the focal length (35 mm film equivalent).

In case the camera has a mechanism for image stabilization (IS), a longer exposure time than the handheld limit exposure time can still produce reasonably sharp images. In this case, image stabilization performance *according to* CIPA DC-011[5] *(number of stops) shall be reported together with the results.*

A.3 Exposure level

IEC 61146-1[3] defines an image as being too dark if the 18 % grey gets reproduced to a digital value lower than the representation of L^* 25. For 8-bit sRGB images, this is equivalent to a digital output value of 59.

A.4 Noise

An average visual noise level of above 5 is the threshold for an image being unacceptable.

A.5 Texture

The 10 % modulation threshold is at least 0,5 × the frequency of the 10 % modulation threshold of the reference image or 600 lp/ph (line pairs per picture height, or 1 200 l/ph) whichever is larger.

A.6 Chroma decrease

The mean threshold is 0,4.

Table A.1 — Result table with applied thresholds

light level	Exposure time[a]	Exposure level	Noise	Texture	$C_{decrease}$
1 000 lx reference	0,008 0	127	1	1 450	1
100 lx	0,016 7	127	1,5	1 300	1
50 lx	0,016 7	127	2	1 270	1
25 lx	0,016 7	127	2,3	1 120	1
12,5 lx	0,016 7	125	3	1 085	1
6 lx	0,016 7	120	4	988	0,8
3 lx	0,016 7	115	5	922	0,5
1,5 lx	0,016 7	110	7	900	0,4
0,75 lx	0,033 3	95	8	756	0,3
0,38 lx	0,066 7	80	10	678	0,2
0,19 lx	0,125 0	70	12	599	0,2
Threshold value	0,050 0	59	5	725	0,4

Output pixel count of 4 000 px × 3 000 px.

The low light-performance value of this example camera is 3 lx.

[a] Camera XXX in program mode with auto ISO and handheld limit exposure time of 1/20 s = 0,05 s.

Annex B
(normative)

Test chart

B.1 Chart sizes and background

Figure B.1 shows the chart described in this annex.

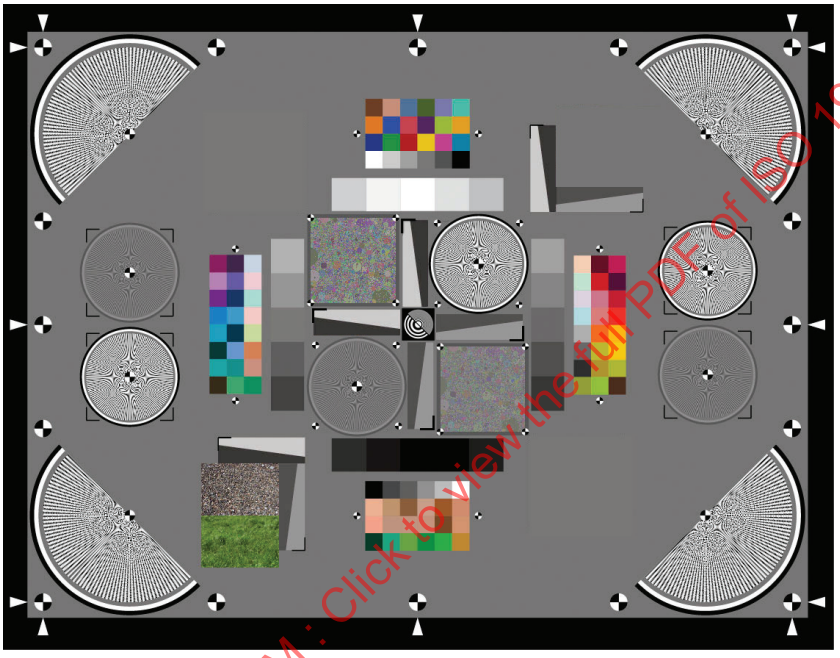


Figure B.1 — Graphical representation of the example chart TE42 v2

The active area of the chart has a nominal size of 900 mm × 675 mm (aspect ratio of 4:3) and is filled with a neutral grey colour of 18 % reflectance. The active area is placed on a black background.

In the following part, all sizes and positions are stated for the nominal size and in values relative to the active chart height in case the chart is produced in a size different than the nominal one. All sizes and positions shall be kept within a ±1 mm tolerance.

White arrows on the black background in the corners and the centre of each borderline of the active area simplify the adjustment of the camera to capture the active area.

B.2 Mandatory features

B.2.1 Focusing aid

A structure with concentric black and white circles equal to the one in the ISO 12233 resolution standard is located in the centre of the chart to ensure optimum auto focus results. The size of the structure is 38 mm × 38 mm (0,563 % × 0,563 % of chart height).

B.2.2 OECF patches

The central Siemens star is surrounded by 20 OECF patches arranged in rows of 5 patches of 40 × 40 mm (5,93 % × 5,93 % of image height) on each side. The grey levels of the OECF patches are calculated according to a 1 000:1 contrast ISO 14524 chart. The distance of each row to the centre is 150 mm (22,22 % of chart height)

B.2.3 Siemens stars

For resolution analysis and focus optimization a sinusoidal Siemens star with 144 cycles and a central mark as described in ISO 12233 with a diameter of 100 mm (14,81 % of chart height) is located 100 mm (14,81 % of chart height) from the centre of the image at 45°. The star is surrounded by a grey circle with a width of 2,5 mm (0,370 % of chart height), a white circle with a width of 2,5 mm (0,370 % of chart height) and a black circle with a width of 2,5 mm (0,370 % of chart height) for optimization of the normalization of the SFR measurement. 4 markers for automated ROI detection surround the star, forming a regular grid of 95 mm × 95 mm (14,07 % of chart height) around the centre of the star.

A second sinusoidal star with the same amount of cycles, the same diameter and markers but a contrast reduced to 18 % as stated in ISO 19567-1, is located at the same distance but at an angle of 225°.

Four half stars with 200 mm (29,63 % of chart height) diameter are located in the corners as shown in Figure B.2.

B.2.4 Colour patches

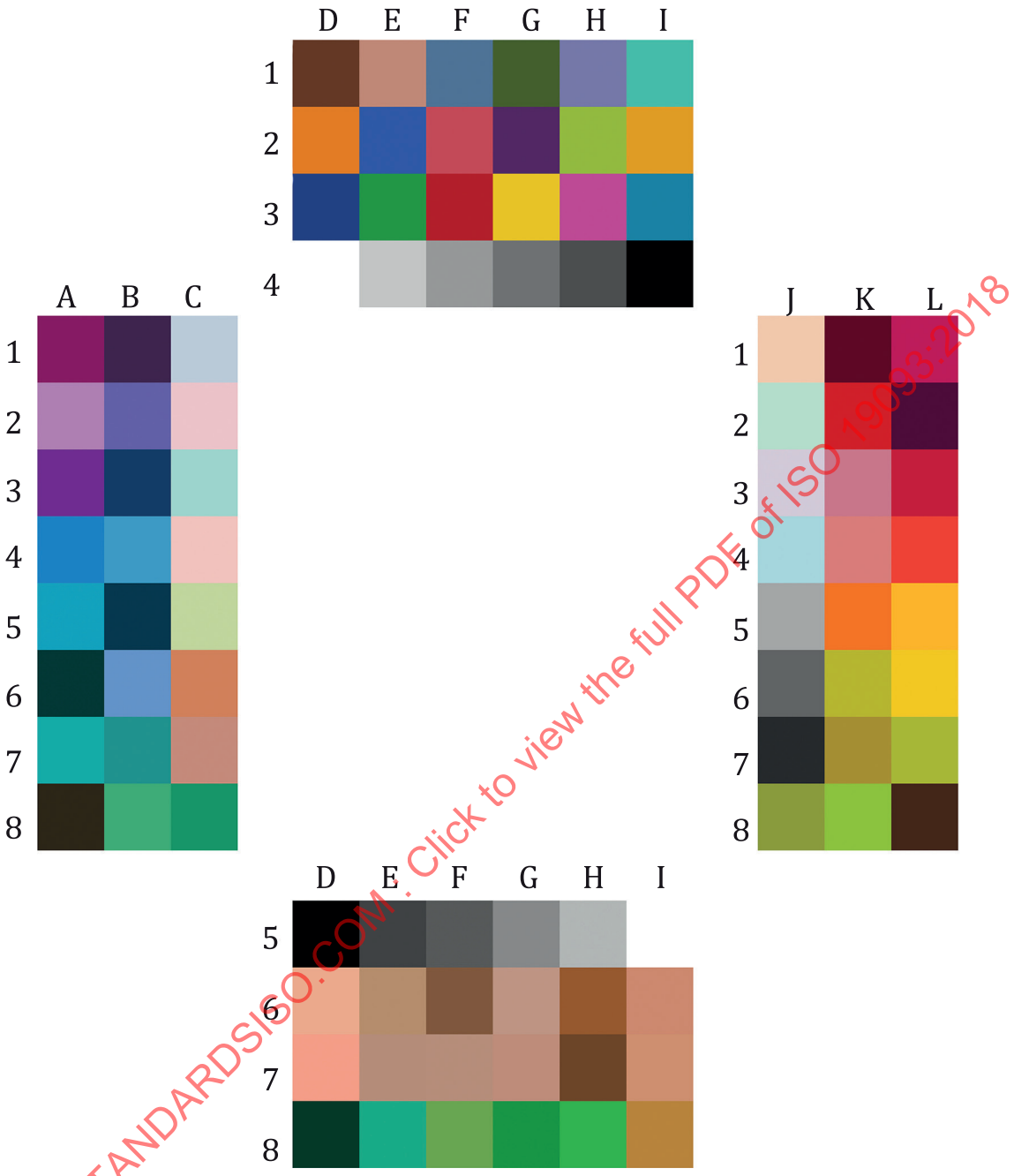


Figure B.2 — Colour-patch naming of the example chart TE42 v2

Only the colour patches in the top part of the test chart as displayed in Figure B.1 named D1 – D3, E1 – E3, F1 – F3, G1 – G3, H1 – H3, I1 – I3 are mandatory, the other patches are optional.

Outside of the grey circle are 20 mm × 20 mm (2,96 % × 2,96 % of chart height) colour patches aiming for the following colorimetric values (D50 and 2° observer). The centre of the left and right block with the patches is 210 mm (31,11 % of the chart height) from the centre of the chart. The centre of the upper and lower with the patches is 220 mm (32,6 % of the chart height) from the centre of the chart.