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Photography — Digital cameras — Measuring low-light performance

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

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Foreword

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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).

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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

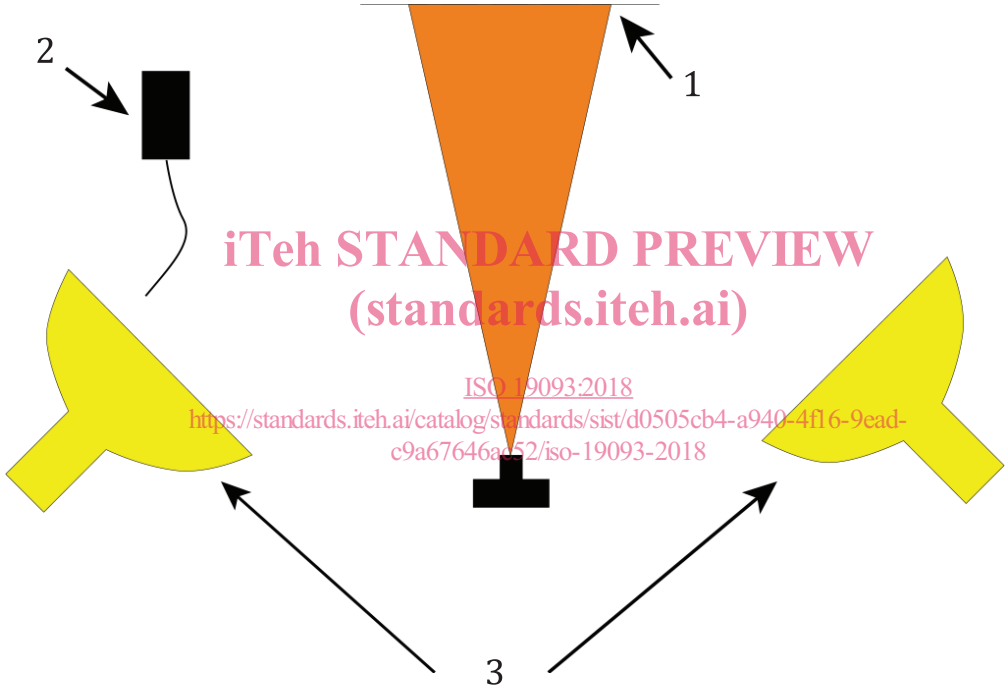
3.3
full frame sensor
image sensor that fills the full 24 mm × 36 mm image size of the 35 mm film format

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.

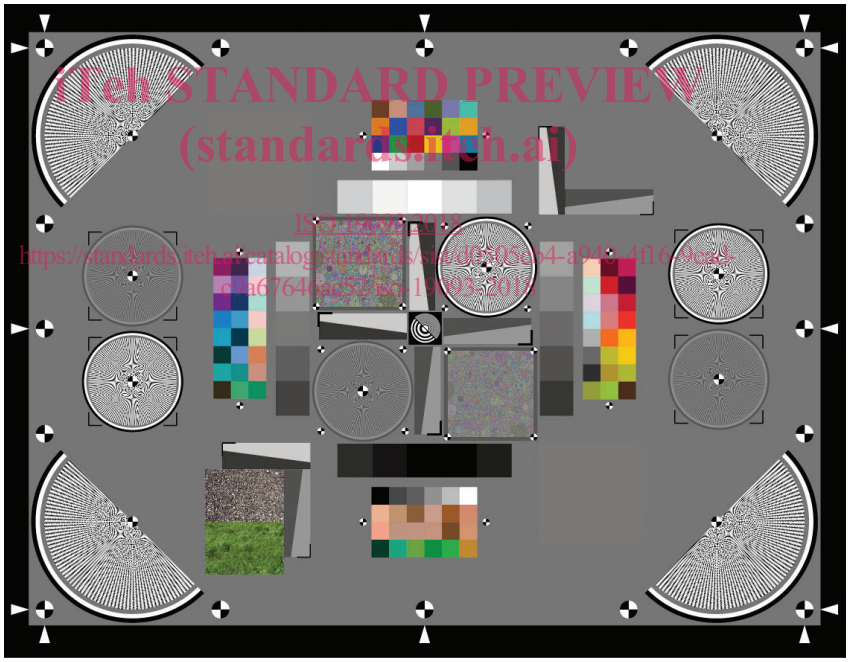


Figure 2 — An example for the multi-purpose test chart

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).