TECHNICAL REPORT

ISO/TR 19247

First edition
2016-07-01

Photography — Guidelines for reliable testing of digital still cameras

Photographie — Lignes directrices pour des essais fiables des caméras numériques

Reference number
ISO/TR 19247:2016(E)

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

Contents

Page

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 on 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.

The committee responsible for this document is ISO/TC 42, *Photography*.

Introduction

The motivation for producing these guidelines for testing digital still cameras (DSCs) is the increasing use of tests by industries and the press. On one hand, the booming DSC market attracts published evaluations and comparisons of its products. On the other hand, complex and, more importantly, reliable testing needs expensive test equipment and experienced and knowledgeable testing technicians. This guide provides direction and procedures for reliable testing of DSCs for those people with neither a photographic nor a scientific background.

The growing commercial development of DSC test methods and equipment is additional motivation for producing these guidelines as it is often difficult to make specific assessments about the usability of new test equipment and methods and about the reliability of their results. For the credibility of test methods and equipment the disclosure of the measurement methods and the mathematical analysis used by the manufacturer of the test equipment is important.

These suggestions follow two goals in order to improve the current situation for the parties involved:

a) Technical guidelines for the testing process

   This guide gives an overview of the important, useful and useable test criteria, procedures and basic evaluation for the users and producers of test methods. It will help to avoid typical mistakes and will improve and secure the validity and reliability of the used methods.

b) Guidelines for the interpretation of test results

   At the moment, there are no guidelines by which the receiver and user of test results, especially magazine readers and digital camera producers, can estimate the reliability and practicability, or in extreme cases the credibility, of test results. This guide will provide support in securing a basis for the assessment, analysis and even discussion with the testers. Therefore, this guide will provide more transparency in this complex area.

Photography — Guidelines for reliable testing of digital still cameras

1 Scope

This Technical Report is applied to the reliable testing of digital cameras (DSCs).

2 Tests based on visual analysis

2.1 General

The visual analysis of digital image data using test persons is not easy as it seems. This becomes more evident when one considers that digital images are not visible. In order to visualize an image, a device needs to be used, i.e. a monitor or a printer.

In order for the correct interpretation of the image data to be possible, it is important to assure that the visible representation created by the device doesn't have any imponderable or even unknown limitations. This means that the devices needs to be calibrated and profiled, and with the help of a suitable colour management workflow allow the correct reproduction of the image. The tester needs to know about the limitations that can be introduced by the device especially in the areas of colour and resolution. Use DIN 15708-1 as a guideline to find out if an acceptably good colour reproduction is available.

It is important to consider that in some cases not all colours from the test specimen can be correctly captured and that colours, which are accurately captured, are not always correctly reproduced on the display or paper.

As a prerequisite for the test person, their ability to see especially with reference to dyschromatopsia (see Ishihara Test) and lack of 20/20 vision shall be given and tested. It is preferable that the test persons be composed of people of different sex and age, so that a representative selection of basic population can be achieved. When the testing starts, all test persons need to be relaxed and healthy. ISO 20462-3 describes the recommended procedure for subjective evaluation in the "quality ruler method".

Table 1 shows the magnitude of the influence of a single person in a group of persons on the median of the subjectively acquired evaluation results. This is derived from the standard deviation:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\bar{x} - x_i\right)^2} = \sqrt{\frac{1}{n-1}}\sqrt{\sum_{i=1}^{n}\left(\bar{x} - x_i\right)^2} \tag{1}$$

The factor $e = \sqrt{\frac{1}{n-1}}$ in Table 1 represents the impact of a single person on the result based on the total number of observers. It is the standard deviation normalized to the square root of the sum of all squared deviations.

$$e = \frac{s}{\sqrt{\sum_{i=1}^{n}\left(x - x_i\right)^2}} = \sqrt{\frac{1}{n-1}} \tag{2}$$

Table 1 — Influence of a single measurement on median of subjective results

Number of test persons	*e*
1	∞
2	1,00
3	0,71
4	0,58
5	0,50
10	0,33
20	0,23
30	0,19
50	0,14
100	0,10

The number of test persons needs to be large enough. Using less than 5 subjects is generally insufficient for a qualified evaluation.

2.2 Tests under conditions which are not replicable

It is preferable that tests fulfil as many of the criteria outlined in 3.2 as possible so that the results are as meaningful and useful as possible. When using a comparative product test, those tests made under conditions that are not replicable are not acceptable. Tests run under conditions that are not replicable are usable only be used as a rough indication of the image quality and are not suitable for reliable conclusions.

2.3 Simple tests under conditions which are replicable (with few test persons)

It is preferable that the following conditions are ensured by those responsible for the testing of the evaluation of image quality under conditions that are replicable.

a) The image display equipment needs to be calibrated and profiled accordingly.

b) Provide complete and accurate documentation for the colour space, reproduction devices, and reproduction media used.

c) Test persons are at least 5.

d) The image quality evaluation scale needs to be clearly defined before beginning the tests.

e) All test criteria are to be collected on the same evaluation scale in order to avoid mistakes and confusing the test persons.

f) As part of the test and before evaluators are asked to evaluate image samples, it is suggested that the evaluators are shown reference samples of nominally excellent quality and nominally poor quality on the quality evaluation scale with an explanation of images captured by the DSC are ranked with respect to these reference images.

g) The image quality aspect that is to be evaluated, needs to be represented in the motif captured by the device under test. Scenes that illustrate one or more of the following image quality aspects should be identified or created. Sample images for reference and evaluation should be made from these scenes.

   1) For the subjective evaluation of colour, an adequate number of relevant colours needs to be present in the photographed objects. This especially includes the green tones of different plants, different light and darker skin tones and blue tones, which occur in pictures of the sky when the sun is shining; as well as grey tones and highly saturated colours, for example in flowers. In addition, colour, which are mixed from the primary colours of cyan, magenta or

yellow represented in different brightness and saturation levels are useful because these often show significant deviations between the original and the captured image.

2) For the subjective evaluation of the dynamic range in the images, specular highlights reflecting off metallic surfaces and dark structures in shaded image areas can be useful. Sufficient detail is also important in the mid tones of the image.

3) For the subjective evaluation of the image sharpness, fine structures distributed throughout the image, including the corners of the image are useful, especially structures with varying orientation (for example Siemens stars or other contrast rich patterns like, for example, the bristles on a brush).

4) If the corner shading is to be subjectively evaluated, an evenly lit partial area in the image that stretches from the centre to the image corners is important.

5) The evaluation of distortion in the image needs a regular grid of structures such as straight lines, which are suggested to be horizontally and vertically oriented (for example, in quadrangle test charts or edges of buildings).

6) If the chromatic aberration in the images is to be subjectively evaluated, then it is useful to have contrast-rich and colour-neutral light to dark transitions in which, especially in the image corners, colour fringes can be identified.

7) For the subjective evaluation of flare, images can be taken in which light sources outside of the image field can be directed at the camera lens.

8) For the subjective evaluation of face recognition functions, it can be useful to capture several photographed faces at a time using different object distances. The situation is made more difficult when a light and contrast-rich scene with an obviously different distance to that of the faces is placed in the centre of the image.

h) If using fewer than 20 test persons, it is best that each person evaluates each image twice.

i) The sequence of the images to be examined is suggested to be randomly altered before each cycle in order to prevent a systematic bias.

j) In each cycle, it is preferable that not more than 15 images to 25 images are examined depending on the number of criteria to be evaluated. After this, it is preferable that test persons are given a suitable break.

k) In each cycle, it is preferable that there are at least one good and one bad reference image of a previously determined quality included.

l) Drastic deviations by individual test persons need to be reported to those responsible for the testing and discussed with those persons. If this deviation remains, then it is preferable that this should be commented and documented.

NOTE The literature sources on the subject of subjective evaluation of the image quality are Reference [19] and the ISO 20462 series.

3 Tests based on technical measurements

3.1 Catalogue of individual technical aspects and suggestions

3.1.1 General

The following technical aspects are relevant for the characterization of cameras. Depending on the use case of the camera, the individual aspects are more or less important. Based on the importance, a subset of the aspects can be selected and measured. It, however, is not sufficient for a complete camera characterization if only a few aspects are used.

For all aspects DIN, ISO and other standards, which establish a corresponding measurement procedure are mentioned if available.

3.2 Test criteria

3.2.1 General

The purpose of test criteria is to describe how far a camera is able to fulfil the different practical needs of a user. They shall, therefore, be orientated to natural scenes and practical needs and not just be a physical unit without relevance to real photographic experience.

The following aspects are suggested as criteria:

a) resolution, also throughout the image field (see ISO 12233);

b) reproduction (loss) of low contrast fine detail (sometimes referred to as texture, ISO 19567-1);

c) opto-electronic conversion function (OECF, ISO 14524);

d) input dynamic range (referring to the scene contrast; see ISO 15739);

e) output dynamic range (referring to the used digital value range in the image);

f) image noise (see ISO 15739);

g) colour reproduction accuracy (see ISO 17321 and CIE 15[20]);

h) geometric distortion (see ISO 17850);

i) image circle illumination, corner shading, vignetting (see ISO 17957);

j) white balance (under daylight conditions).

k) further interpretation of the OECF-curve development (see ISO 14524);

l) acutance, sharpness (to be derived from MTF measurement according to ISO 12233);

m) chromatic displacement (including lateral chromatic aberration and ISO 19084);

n) shutter and shooting time lag (see ISO 15781);

o) further characterization of image noise and its colour and luminance components (visual noise, etc.; see ISO 15739);

p) compression leading to artefacts;

q) visual evaluation of aliasing;

r) low light performance;

s) flare, stray light, false light;

t) number of defect pixels;

u) determining the longitudinal chromatic aberration;

v) battery life (see ISO 20087).

3.3 Test conditions

It is preferable that the test condition and the camera settings are selected in a way to make sure that the camera's mode of operation fulfils the statistically most significant and comparable setting used in practical photography. This way, the measurement results retain a realistic relevance and

comparability. This would not be possible if the camera were to work in a mode, which reflects a very small part of the real scenes (i.e. testing the macro-modus with an A4 sized test sample). Likewise, improper test characteristics lead to measurement inconsistency or to influencing the future reliability of the procedure.

Some of the notable test conditions are as follows:

a) uniform lighting is especially needed for shading measurements or the internal calibration using a reference image;

b) colour temperature of the light source near 5 500 K (D55, ISO 7589) or if other light sources are used check internal calibrations for other colour temperatures. Make sure the light source offers a relatively continuous spectrum (ideally, a close spectral match to D55);

c) minimum object luminance resulting in EV 7 (light value according to ISO 2720) for standard tests like resolution, distortion, shading, colour, etc. and *EV* 11 for OECF tests with high contrast OECF Charts;

d) minimum size of the test chart when measuring compact cameras of 40 cm × 60 cm (approximately 20 times the focal length for 35 mm film camera) for measuring the resolution, chromatic aberrations and distortion in case the test is designed for standard photography; smaller charts are important in case of the evaluation of macro capabilities.

e) environmental conditions during testing: temperature 23 ± 2 °C, relative humidity 45 % ± 15 %;

NOTE The thermal noise of the solid-state sensor in a DSC roughly doubles with a temperature increase of 10 °C.

f) suitably calibrated and profiled monitor for visual analysis of the results;

g) variation of different colour temperatures for testing under different lighting conditions.

Some of the notable device characteristics are as follows:

— standard settings for focus, contrast, colour saturation, ISO-sensitivity, white balance, and others that are checked for plausibility and reproducibility (in particular, avoid auto-ISO settings);

— parameters (such as focus) that are influenced by interchangeable lenses and that might be the limiting factor in the measurement conclusions concerning the camera body.

3.4 Software and samples

3.4.1 Test charts

Test charts, on the whole, need to be composed in a neutral way so that they deliver useable and reliable results with the camera's automated exposure measurements and automatic white balance. It is preferable that exposure compensations are kept to a minimum.

It is important that all measuring equipment especially the test charts have a significantly better quality than the best anticipated measurement result. In most cases the quality produced when using a home printer is not sufficient for camera testing. Targets need to fulfil the requirements mentioned in the individual standards.

3.4.2 Evaluation of images

It is highly recommended to use software that was developed for image analysis. The normal analysis, i.e. with standard image processing software contains many sources for error (i.e. false colour adjustments in the software or errors when reading and transferring the data).

3.5 Archiving and documentation

Document and archive the following information:

a) the procedure and specific measurements for transparency and reproducibility;

b) the camera settings;

c) the handling of camera settings and image data;

d) the original data with the metadata;

e) the duplication and other steps to provide for data safety.

3.6 Minimization of deviations

The reliable execution of a test highly depends on the quality and suitability of every individual piece of test equipment. Therefore, make sure it is carefully manufactured and selected. AF problems and optical decentration can potentially lead to wrong results and put the reliability of the method in question. For this reason, the following assessments are ideally executed before the implementation of every test:

a) Check the correct autofocus (AF) of the individual device. Here, it is not enough to do a functional check to see if the AF is working, rather it is important to execute a test measurement with a suitable resolution chart including an estimation of the results. Cameras that do not use the contrast-autofocus as a default are preferably switched to this type of focus adjustment. If there isn't a contrast-autofocus available, then the resolution measurement is preferably established by using a manual focus series.

b) Check the correct optical centering of the individual device by using a suitable resolution chart according to ISO 12233; derive a quantitative difference between the resolutions (frequency where the MTF10 reaches the 10 % contrast level) in the four image corners and terminate the measurement if a deviation of more than 10 % between the max and the min of the corner resolution is determined.

3.7 Preparation of personnel for reliable testing

The development and implementation of test procedures shows that a reliable measurement cannot be assured through an available measurement system alone. Personnel who affect the measurements need to have technical and practical experience in order for them to be able to understand, recognize, and evaluate the different characteristics of the devices to be tested. One way to ensure experience as explained is a degree in photographic technology or working as a professional photographer for several years.

While testing procedures that are not based on any special expertise are included here, it is important to give personnel not only technical knowledge of the measurement system, but also to convey to them the basic requirements and general problems of practical photography, information about the technical mechanisms in DSCs, and the guidelines in this Technical Report for reliable testing.

Ideally, inexperienced personnel are educated to understand the requirements for the reliable testing of DSCs by experts.

The following points need to be kept in mind as well:

a) If technically experienced staff perform tests, error-tolerant measurement setups can be used. In this case, it is sufficient to log any unusual deviations.

b) For tests performed by technically inexperienced staff, for example people who did not study photographic technology or worked as professional photographers for a long periods of time, it is preferable that error-intolerant measurement systems are used. Through a number of evaluation

