TECHNICAL REPORT

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Photography — Photographic reflection prints —

Part 1: Evaluation methods of image quality

Photographie — Tirages photographiques par réflexion —

Partie 1: Méthodes d'évaluation de la qualité de l'image

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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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*.

A list of all parts in the ISO 20791 series can be found on the ISO website.

Introduction

Image quality of photographic prints is not based on any single feature but instead involves several factors. There are so-called “five major properties” for representing photographic image quality, and each one is essential: (1) density; (2) colour; (3) uniformity; (4) tone and (5) detail reproduction. Glossiness represents another important factor. It affects the observer’s perception since it relates to the light specularly reflected from prints. Though the specularly reflected light contains no information from the printed image, it affects the observer’s perception. Furthermore, sharpness of the shape of reflected light sources also affects the perception.

Several standards for image quality measurement have been documented by ISO/TC 42. Standards intended for analogue prints fail to properly address the effect of half tone dots, which required to produce inkjet and electrophotographic prints.

In recent years, the field of imaging science and technology has witnessed the investigation of measurement methods for digital prints. In addition, standards have been developed by ISO/IEC JTC 1/SC 28 and ISO/TC 130. Some of these standards cannot be applied broadly to photographic prints because they focus on a specific technical or industrial field. However, the rest of these standards handle common aspects and can be applied to photographic prints with or without modifying the standard. This document provides information about the measurement methods for image quality that are applicable to photographic prints, including digital prints produced using a range of printing technologies.

ISO/TC 42 plans to develop test targets for image quality measurements on small size photographic prints. This document provides methods which can be applied for the measurements.

Photography — Photographic reflection prints —

Part 1: Evaluation methods of image quality

1 Scope

This document provides information and examples of measurement methods for evaluating the image quality of digital photographic reflection prints, including prints produced by ink jet, thermal dye transfer, electrophotography and silver halide (chromogenic) technologies. These measurement methods are intended especially to be applicable to small prints with a size of available picture area ranging from 35 mm × 45 mm to 360 mm × 450 mm, a popular and basic application of photographic print technology.

NOTE The definition of "digital print" here is print made directly from digital data when there is no intermediate image carrier, or when the image carrier is refreshed for each impression, and thus each impression can be different in content if desired.

2 Normative references

There are no normative references in this document.

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 Terms

3.1.1
reflectance factor
ratio of the reflected flux as measured to the reflected flux under the same geometrical and spectral conditions for an ideal 100 % diffuse reflecting surface

[SOURCE: ISO/IEC 24790:2017, 3.30]

3.1.2
spots per inch
spi
spots per 25,4 mm

[SOURCE: ISO/IEC 24790:2017, 3.34]

3.1.3
visual transfer function
VTF
function used to represent human visual characteristics when dividing the system into parts and evaluating it as a superposition of transfer functions in the spatial frequency domain

3.1.4
mura
non-uniformity in the image that should be of uniform density or uniform colour

Note 1 to entry: Mura defects are larger than graininess or mottle, and it generally has ambiguous boundaries.

3.1.5
addressability
number of uniquely identifiable printable spot positions per unit distance

[SOURCE: ISO/IEC 29112:2018, 3.1.1]

3.1.6
area modulation
method of expressing gradation by changing the size or the frequency of dots

3.1.7
density modulation
method of expressing gradation by changing the density of pixels

3.1.8
contrast transfer function
CTF
ratio of the image contrast to the object contrast of a square-wave pattern as a function of spatial frequency

[SOURCE: ISO/TR 19319:2013, 2.2, modified — Notes 1 and 2 to entry were deleted.]

3.1.9
modulation transfer function
MTF
spatial frequency response
SFR

ratio, as a function of spatial frequency, of the measured modulation response in a print produced by a printing system, to the stimulus modulation presented to that printing system

[SOURCE: ISO/IEC 29112:2018, 3.1.16]

3.1.10
line spread function
LSF
normalized spatial signal distribution in the linearized output of an imaging system resulting from imaging a theoretical infinitely thin line

[SOURCE: ISO 12231:2012, 3.94, modified — Note 1 entry was deleted.]

3.1.11
specular gloss
gloss observed or measured at the specular angle

[SOURCE: ISO 8254-1:2009, 3.8]

3.1.12
image clarity
degree of sharpness of an image reflected by a specimen or transmitted through a specimen

[SOURCE: ISO 17221:2014, 3.1, modified — Note 1 to entry was deleted.]

3.2 Abbreviations

R	red
G	green
B	blue
V	visual
CIE	International Commission on Illumination
CIELAB	CIE 1976 ($L^*a^*b^*$) colour space
dpi	dots per inch
spi	spots per inch
cy/mm	cycle per millimetre
DOI	distinctness of image

4 Overview of the photographic print image quality

4.1 General

It is commonly understood that there are five major properties for representing the image quality of photographic prints, and each one is essential in representing the overall image quality. Each property can be further classified into several sub-properties. Table 1 presents these categorised properties and some related examples of measurements.

Table 1 — Overview of properties and measurement methods

Property	Sub-property	Related measurement methods
(1) Density	a) Optical density	— Optical density R, G, B and V values for white, grey, black and each colour step
(2) Colour	a) Chromaticity	— Colorimetric value in colour space
	b) Colour gamut	— Coverage in colour space (area, volume)
(3) Uniformity	a) Micro uniformity	— Granularity and graininess (tens to hundreds of micrometres)
	b) Semi-micro uniformity	— Mottle (hundreds to thousands of micrometres)
	c) Macro uniformity	— Non-uniformity in print area, such as mura, banding and shading (thousands of micrometres to the whole printing area)
(4) Tone	a) Tone reproduction	— A characteristic of a printing system how colour or density is modulated by the change in the intensity of input image signal to the system.
	b) Capacity for tone reproduction	— Number of tonal steps
(5) Detail reproduction	a) Detail reproduction	— Contrast transfer function (CTF) property and several “spatial resolution” values

The following aspects should be included when evaluating and measuring digital photographic print image quality, in comparison to that of traditional analogue photographic prints.

4.2 Density and colour

For density and colour measurement, additional colorants should be considered. In addition to cyan, magenta and yellow colorants, black colorant is typically used in many digital printing technologies. In some cases, more colorants, for example, orange or violet colorant, are used to improve density and colour reproduction. Of course, these additional colorants affect density and colorimetric value itself. Moreover, additional colorants can expand colour space because they enable vivid colour reproduction with less turbidity.

4.3 Uniformity

Uniformity measurement includes micro, semi-micro and macro uniformity. Because some digital photographic prints contain a structure of microdots, the dots themselves can be perceived as a sort of micro structure. Displacement of dots or colour registration failure can cause misalignment of microstructure. Misalignment negatively impacts the micro or sub-micro uniformity. Such attributes should be a concern, especially for digital photographic prints.

NOTE Dot size (or dot area), dot gain, dot placement accuracy, and colour bleed are important parameters for analyzing the image quality described in this document. Rosettes, moiré and reticulation streaking are also important parameters to consider when assessing the image quality of digital prints.

4.4 Tone

For tone measurement, the capacity for tone reproduction should be addressed in addition to tone curve. Depending on the original digital image file format, the image's capacity to differentiate pixel tone is limited; for example, 256 levels for 8-bit format, 1 024 levels for 10-bit format. It is important to measure the distinguishability of each of the available levels in the printed image.

4.5 Detail reproduction

Regarding detail reproduction, micro image structures directly affects how finely an image can be represented. However, there are many kinds of micro image structure now present in digital imaging across the variety of print technologies. For digital prints especially, one should be concerned with how the image is perceived by human eye. This is crucial when comparing the properties of prints produced with different printing technologies.

4.6 Glossiness

In addition to the five major properties above, reflective properties such as glossiness need to be addressed for all photographic prints but especially for digital photographic reflection prints. In traditional silver halide prints, colour images are generated inside the surface gelatin layer. However, in many types of digital print technologies, colorants are set on substrates, so that colorants themselves form some parts of the print surface. Thus, the intensity and uniformity of the light reflected from such prints will change depending on the illumination under which a print is observed.

4.7 Others

The above measurements address the quality of a given print, but the variation or repeatability of image quality among multiple prints is another important aspect. Colour variation affects not only identity in print duplication but also overall quality of a print series; for example, a photo book that includes various scenes in a specified sequence.

In this document, measurement methods for five major properties are described in the following clauses, from Clause 5 to Clause 9. In addition to the five major properties, glossiness measurement methods are described in Clause 10. Colour variation in printing will be described in another document of the ISO 20791 series (future ISO/TS 20791-2).

5 Density

Density can be measured according to ISO 5-3[7] and ISO 5-4[8]. With these methods, the red (R), green (G), blue (B) and Visual (V) density values can be assessed in a single measurement. A test chart for density measurements consists of several patches of sufficient size to be measured with an applied densitometer. A typical test chart is shown in Figure 1. It has grey, cyan, magenta, yellow, red, green and blue tone patches, with the numerical digital value at equal intervals. The maximum density of each colour and the density of D_{min} patch in the test chart are especially important. The results of density measurements can also be used to evaluate the gamma attribute, as well as tone curve.

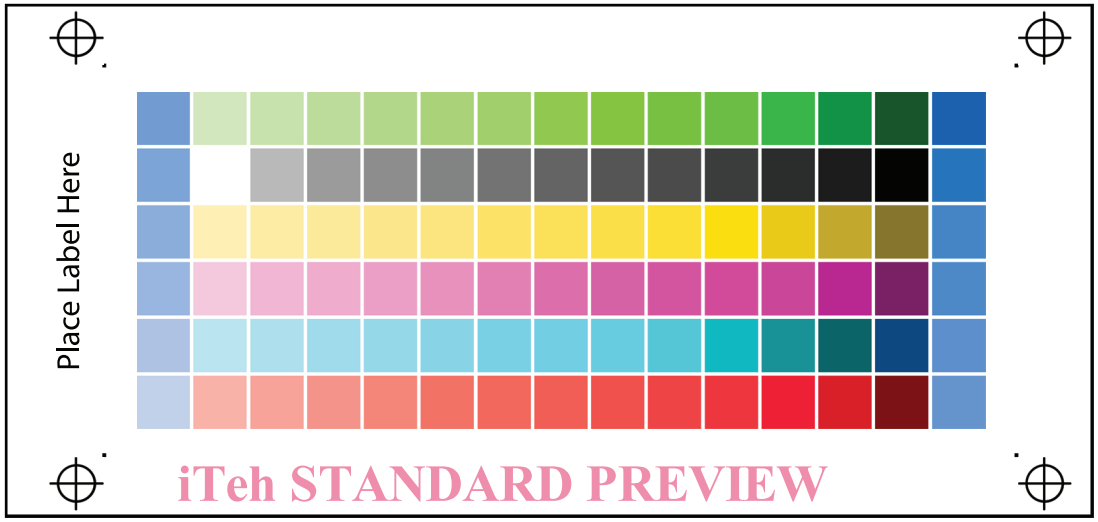

Figure 1 — An example of a test chart for density and colour measurements (ISO 18944[9])

6 Colour

Chromaticity can be measured according to ISO 11664-1[10], ISO 11664-4[11] and ISO 13655[12]. With these methods, colorimetric values L^*, a^*, and b^* in CIELAB 1976 colour space can be assessed in a single measurement and subsequent calculations. Conforming to ISO 13655, CIELAB values are computed using CIE illuminant D50 and the CIE 1931 standard colourimetric observer (often referred to as the 2° standard observer). Other illuminants can be used depending on circumstances and purpose of the measurement. A test chart for chromaticity measurements consists of several patches of sufficient size to be measured with an applied colorimeter. An example test chart is shown in Figure 1. Grey, cyan, magenta, yellow, red, green, blue and white patches are fundamental components of the test chart. Special colours can be added, for example, skin tones, leaf green and sky blue.

In addition to colorimetric value itself, coverage in colour space is an important concern for digital photographic prints. Since a^*-b^* chromaticity diagrams represent considerable information while remaining visually simple, they have been used widely in photography analysis. Examples of an a^*-b^* chromaticity diagram are shown in Figure 2.