
Photography — Lenticular print for changing images — Measurements of image quality

*Photographie — Impression lenticulaire pour images changeantes —
Mesurages de la qualité des images*

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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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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

Lenticular printing is a technology wherein lenticular lenses are used to produce printed images with an illusion of depth, i.e. three-dimensional (3D) effect, or the ability to change or move as the image is viewed from different angles. Lenticular prints to display changing images are built up with a lenticular lens sheet and a printed sheet that contains at least two images, interleaved with the same spacial frequency as the lenticular lens sheet.

Lenticular lenses are an array of magnifying lenses.

Widespread applications of lenticular printing are signage, display posters, business cards, multilingual message boards and packages with changing images or 3D effects.

It has been reported that the market size of lenticular prints is over 100 million m² and that the market is growing. Furthermore, the potential image qualities of lenticular printing have dramatically improved and further improvements are expected in the future. While production of lenticular sheets with a lens frequency of 100 lpi (lines per inch) is routine, products with a 200 lpi frequency are also currently available.

Although the potential image quality of lenticular prints is high as described above, the quality of images is not always good in the market due to various causes, e.g., due to the misalignment of the lenticular lens and lenticular printed images. This is a critical problem for lenticular printing.

To improve the image quality of lenticular prints, image quality measurements are essential. This document provides standard measurement methods and the specifications for the image quality of lenticular prints.

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Photography — Lenticular print for changing images — Measurements of image quality

1 Scope

This document specifies the measurement methods and specification of image quality of lenticular prints that are used for changing images. This document does not cover lenticular prints that are used for 3D images.

NOTE Lenticular prints for 3D images can be measured with the same types of procedures. However, it needs more information, such as the dependence of the measurement distance, to evaluate the 3D performance.

This document specifically describes measurement methods for cross-talk, viewing angle range, angular misalignment from the designed viewing angle and the uniformity of the image within the printing area of the lenticular print images. These are critical for the image quality of lenticular prints for changing images.

This document is applicable to lenticular prints produced by printing technologies that include impact and non-impact printing. Examples of the former are off-set, gravure and flexography, while the examples of the latter are silver halide, inkjet, dye diffusion thermal transfer and electrophotography. The multiple laser images (MLI) and changeable laser images (CLI) process of using a laser to write through a lenticular screen at different angles to create multiple images is also used.

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 5-3, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*

ISO 5-4, *Photography and graphic technology — Density measurements — Part 4: Geometric conditions for reflection density*

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

lenticular lens

array of magnifying semi-cylindrical lenses, designed to produce a desired perception, such as 3D, motion or morphing, to the underlying interlaced image

EXAMPLE This technique is widely used in lenticular printing, wherein the lenticular lens is used to provide an illusion of depth, change or motion to an underlying interlaced image when viewed from different angles.

[SOURCE: ISO/TS 20328:2016, 3.1, modified — Note 1 to entry has been removed.]

3.1.2

lenticular print

print combined with lenticular lenses which produces printed images with an illusion of depth, i.e. three-dimensional (3D) effect, or the ability to change or move as the image is viewed from different angles

Note 1 to entry: The detailed explanation of lenticular print is provided in [Annex A](#).

Note 2 to entry: Lenticular prints to display changing images are built up with a lenticular lens sheet and a printed sheet that contains at least two images, interleaved with the same special frequency as the lenticular lens sheet.

3.2 Abbreviations

CIE	commission internationale de l'éclairage (International Commission on Illumination)
CTP	computer to plate
LMD	light measuring device
LPS	lenticular print sample
RGB	red, green, blue

4 Standard environmental conditions

4.1 Temperature and humidity

The standard environmental conditions shall be applied for the measurements of lenticular prints. The standard environmental conditions shall be a temperature of $23\text{ °C} \pm 3\text{ °C}$ and a humidity of $50\% \text{ RH} \pm 15\% \text{ RH}$.

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4.2 Ambient illumination conditions

For standard dark room conditions, the ambient illuminance at any position on the lenticular print is below 0,3 lx in all directions or the illuminance shall at least be less than a level that does not influence the measurement results.

When directional illumination is used, standard dark room conditions shall be applied unless the instrumentation used is effective in suppressing background illumination.

When the sample is set in an integrated sphere, dark room may not be required.

5 Measurement conditions

5.1 General

For the measurements, the lenticular print samples shall be illuminated with hemispherical diffuse lighting. Directional illumination can also be used when it is appropriate for simulating the use application.

The reflected light from the print sample shall be measured using a spectroradiometer.

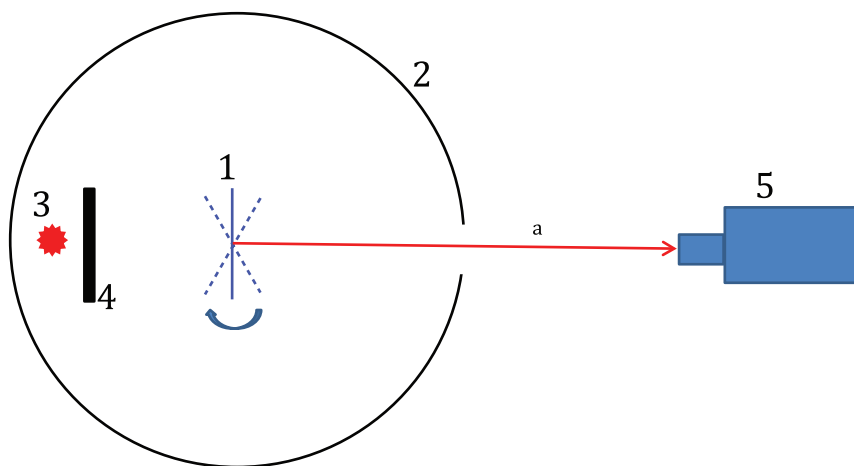
5.2 Geometry of measurements

5.2.1 Standard conditions with hemispherical illumination

Uniform hemispherical diffuse illumination is generally realized by using an integrating sphere. The lenticular print sample (LPS) shall be placed in the centre of an integrating sphere as shown in [Figure 1](#).

For the calibration, the reflection standard, i.e. a standard white board, shall be placed at the same position of the LPS. Best practices for integral sphere design and measurements are described in References [2] and [3].

When the viewing direction dependence is measured, the print sample shall be rotated around the axis parallel to the direction of the array of lenticular lens.



Key

- | | | | |
|---|--------------------|---|------------------------------|
| 1 | lenticular print | 4 | baffle |
| 2 | integration sphere | 5 | light measurement device |
| 3 | light source | a | Reflected light from sample. |

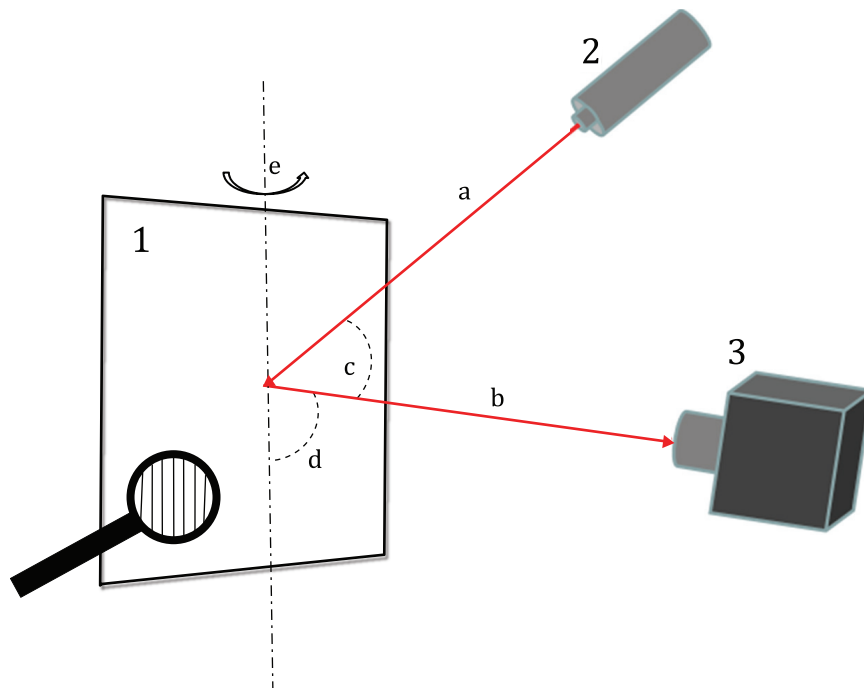
Figure 1 — Geometry of measurement with hemispherical illumination

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5.2.2 Optional conditions with directional illumination

The directional light shall be illuminated at an angle of 45° from the normal, and the reflected light shall be detected from the direction normal to the print as shown in Figure 2. The light source and the detector shall be placed in the same plane. The lenticular print shall first be set normal to the detector, and it shall be rotated from the normal direction in order to measure the viewing angle dependence.

**Key**

- 1 lenticular print
- 2 light source — directional
- 3 detector
- a Incident light.

- b Reflected light.
- c Angle of the incident light = 45° .
- d Angle of the detection = 90° .
- e Angle of rotation of the print.

Figure 2 — Geometry of measurement with directional illumination

5.3 Light source

For the standard conditions, hemispherical illumination shall be applied. The illumination spectra shall be a stable and spectrally continuous broadband visible light source, for example, an incandescent lamp defined as CIE Standard Illuminant A.

5.4 Light measuring device (LMD)

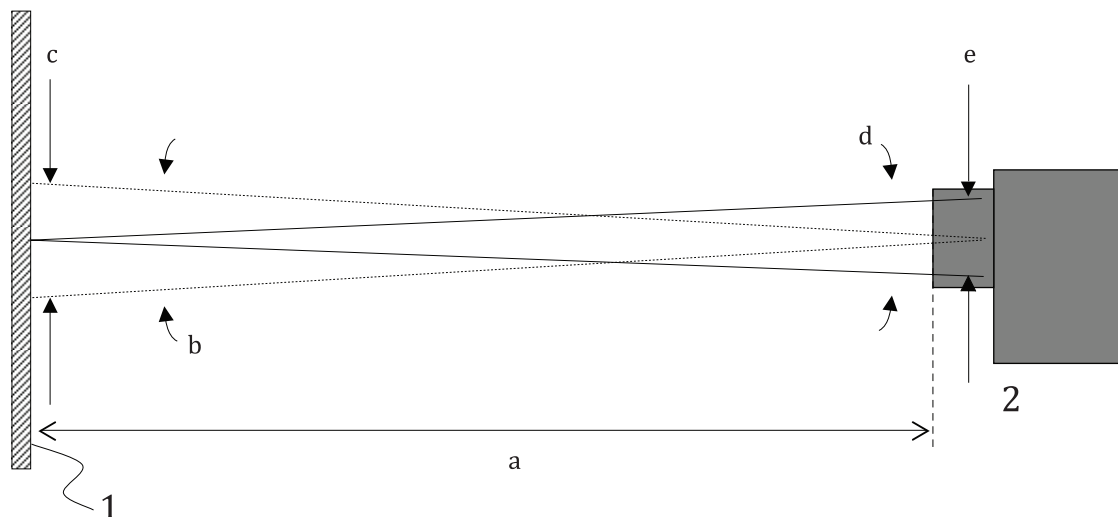
The light reflected from the lenticular print shall be measured. Illuminant D50 shall be applied. The following requirements are given for measurement instrument:

- a) The spectroradiometer shall be capable of measuring spectral radiance over at least the 380 nm to 780 nm wavelength range, with a maximum bandwidth of 10 nm for smooth broadband spectra.

Care shall be taken to ensure that the LMD has enough sensitivity and dynamic range to perform the required task. The measured LMD signal shall be at least ten times greater than the dark level (noise floor) of the LMD, and no greater than 85 % of the saturation level.

- b) The LMD shall be focused on the image plane of the print and aligned perpendicular to its surface, unless stated otherwise.
- c) The relative uncertainty and repeatability of all the measuring devices shall be maintained by following the instrument supplier's recommended calibration schedule.
- d) The recommended measuring distance is between 35 cm to 60 cm. The measuring distance shall be noted in the report.

- e) The angular aperture shall be less than or equal to 5°, and the measurement field angle shall be less than or equal to 2° (see Figure 3).
- f) The measurement field of the LMD shall be centred and enclosed within the illuminated measuring spot on the print.



Key

- | | | | |
|---|---|---|---------------------------------------|
| 1 | lenticular print | c | Measurement area (measurement field). |
| 2 | LMD | d | Angular aperture. |
| a | Measuring distance. | e | Aperture area. |
| b | Measurement area angle (measurement field angle). | | |

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Figure 3 — Layout diagram of measurement setup

5.5 Working standards and references

The LMD shall be calibrated with a diffuse white reflectance standard sample with a diffuse reflectance of 98 % or more. The reflectance shall be calculated based on the reflectance of the perfect white panel and the black panel.

Diffuse white reflectance standard samples can be obtained with a diffuse reflectance of 98 % or more. They are also available in different shades of grey. A luminance L_{std} measurement from such reflectance standards can be used to determine the illuminance E on the standard for a defined detection geometry and illumination spectra and configuration:

$$E = \frac{\pi L_{\text{std}}}{R_{\text{std}}} \quad (1)$$

where R_{std} is the calibrated luminous reflectance factor for that measurement configuration. When the illumination configuration is a uniform hemispherical illumination, then R_{std} is equivalent to luminous reflectance ρ_{std} . The luminous reflectance value associated with the standard is only valid for the hemispherical illumination in which it was calibrated. If it is used with a directed source at any angle, there is no reason to expect that the luminous reflectance value will be the correct luminous reflectance factor value for that illumination configuration or spectra.

The terms luminous reflectance and luminous reflectance factor shall be abbreviated to reflectance and reflectance factor, respectively.

Black glass (e.g., BG-1000), or a very high neutral density absorption filter (density of 4 or larger), can be used to determine the luminance of a source L_s from the measured luminance L_{std} of the virtual

source image as reflected by the black glass, and the luminous specular reflectance ζ_{std} of the black glass for the measurement configuration used:

$$L_s = \frac{L_{\text{std}}}{\zeta_{\text{std}}} \tag{2}$$

When making specular measurements, the detector is focused on the virtual image of the source. Black glass can be considered as a front surface mirror that has a low specular reflectance of between 4 % and 5 %. A black glass standard can be helpful when the measurement geometry does not allow measuring the source luminance directly, but only by using a mirror. The low specular reflectance of black glass allows measuring the source luminance at about the same order of magnitude as the reflection measurement.

The specular reflectance of black glass is affected by the specular angle, the illumination spectrum, and the cleanliness of its surface. The calibration shall be repeated when the measurement geometry is changed.

6 Preparation of lenticular print samples

6.1 Test pattern

The lenticular images are divided by several picture elements for one lenticular lens width, as shown in [Figure 4](#). For the measurements of this document, striped test patterns shall be used, where each strip element shall be white or black, or other primary colours.



- Key**
- 1 lenticular lens
 - a Number of picture element.
 - b Picture elements of lenticular print.

Figure 4 — Schematic illustration of the picture elements of a lenticular print

The test pattern shown in [Table 1](#) shall be applied for the measurement. [Table 1](#) is for 12 picture elements in one lenticular lens width. For other cases, an analogical test pattern shall be applied. [Table 1](#) is illustrated with black and white. For the evaluation of colour images, black shall be replaced with a primary colour of yellow, magenta, or cyan, or a secondary colour of red, green, or blue.