INTERNATIONAL STANDARD

ISO 16067-2

First edition
2004-10-15

Photography — Electronic scanners for photographic images — Spatial resolution measurements —

Part 2: Film scanners

Photographie — Scanners électroniques pour images photographiques — Mesurages de la résolution spatiale —

Partie 2: Scanners pour films

Reference number
ISO 16067-2:2004(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 16067-2 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 16067 consists of the following parts, under the general title *Photography — Electronic scanners for photographic images — Spatial resolution measurements*:

— *Part 1: Scanners for reflective media*

— *Part 2: Film scanners*

Introduction

One of the most important characteristics of an electronic film scanner is the ability to capture the fine detail found in the original film. This ability to resolve detail is determined by a number of factors, including the performance of the scanner lens, the number of addressable photoelements in the image sensor(s) used in the scanner, and the electrical circuits in the scanner. Different measurement methods can yield different metrics that quantify the ability of the scanner to capture fine details.

This International Standard specifies methods for measuring the limiting visual resolution, and spatial frequency response calculated from a slanted edge (Edge SFR) imaged by a film scanner. The scanner measurements described in this International Standard are performed in the digital domain, using digital analysis techniques. A test chart of appropriate size and characteristics is scanned and the resulting data is analysed. The test chart described in this International Standard is designed specifically to evaluate continuous tone film scanners. It is not designed for evaluating electronic still-picture cameras, video cameras, or bi-tonal document scanners.

The edge SFR measurement method described in this International Standard uses a computer algorithm to analyse digital image data from the film scanner. Pixel values near slanted vertical and horizontal edges are used to compute the SFR values. The use of a slanted edge allows the edge gradient to be measured at many phases relative to the image sensor photoelements, so that the SFR can be determined at spatial frequencies higher than the half sampling frequency, sometimes called the Nyquist limit. This technique is mathematically equivalent to a moving knife-edge measurement.

Part 1 of this International Standard deals with reflective media.

Photography — Electronic scanners for photographic images — Spatial resolution measurements —

Part 2: Film scanners

1 Scope

This International Standard specifies methods for measuring and reporting the spatial resolution of electronic scanners for continuous tone photographic negatives and reversal (e.g. slide) films. The International Standard applies to both monochrome and colour film scanners.

2 Normative references

The following referenced documents are indispensable for the application 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 5-2, *Photography — Density Measurements — Part 2: Geometric conditions for transmission density*

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 12231, *Photography — Electronic still-picture cameras — Terminology*

ISO 12233, *Photography — Electronic still-picture cameras — Resolution Measurements*

ISO 14524, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12231 and the following apply.

3.1
addressable photoelements
number of active photoelements in an image sensor

NOTE This is equal to the number of active lines of photoelements, multiplied by the number of active photoelements per line.

3.2
aliasing
reconstructed image artefacts in sampled imaging systems where the combined spatial frequency energy of the input image and scanner combination is significant beyond the half-sampling frequency of the scanner

NOTE These artefacts usually manifest themselves as moiré patterns in repetitive image features or as jagged stair stepping at edge transitions.

3.3
digital output level
numerical value assigned to a particular output level, also known as the digital code value

3.4
edge spread function
ESF
normalized spatial signal distribution in the linearized output of an imaging system resulting from imaging a theoretical infinitely sharp edge

3.5
effectively spectrally neutral
having spectral characteristics that result in a specific imaging system producing the same output as for a spectrally neutral object

3.6
electronic scanner for photographic films
scanner incorporating an image sensor that outputs a digital signal representing a still film image

3.7
fast scan direction
scan direction corresponding to the direction of the alignment of the addressable photoelements in a linear array image sensor

3.8
gamma correction
process that alters the image data in order to modify the tone reproduction

3.9
image sensor
electronic device that converts incident electromagnetic radiation into an electronic signal; e.g. a charge coupled device (CCD) array

3.10
resolution
measure of the ability of a digital image capture system, or a component of a digital image capture system, to capture fine spatial detail

NOTE Resolution measurement metrics include resolving power, limiting visual resolution, SFR, MTF and CTF.

3.11
sampled imaging system
imaging system or device which generates an image signal by sampling an image at an array of discrete points, or along a set of discrete lines, rather than a continuum of points

NOTE The sampling at each point is done using a finite size sampling aperture or area.

3.12
sample spacing
physical distance between sampling points or sampling lines, measured in units of distance (e.g. µm, mm)

NOTE The sample spacing may be different in the two orthogonal sampling directions.

3.13
sampling frequency
reciprocal of sample spacing

NOTE Expressed in samples per unit distance (e.g. dots per inch).

3.14
scanner
electronic device that converts a fixed image, such as a film or film transparency, into an electronic signal

3.15
scanner opto-electronic conversion function
scanner OECF
relationship between the input density and the digital output levels for an opto-electronic digital capture system

3.16
slow scan direction
direction in which the scanner moves the photoelements (perpendicular to the lines of active photoelements in a linear array image sensor)

3.17
spatial frequency response
SFR
R_{SFR}
measured amplitude response of an imaging system as a function of relative input spatial frequency

NOTE 1 The SFR is normally represented by a curve of the output response to an input sinusoidal spatial luminance distribution of unit amplitude, over a range of spatial frequencies. The SFR is normalized to yield a value of 1,0 at a spatial frequency of 0.

NOTE 2 In equations, the symbol R_{SFR} rather than the abbreviation SFR is used for clarity.

3.18
spectrally neutral
test chart in which the relative spectral power distributions of the incident and reflected (or transmitted) light are equal

3.19
test chart
arrangement of test patterns designed to test particular aspects of an imaging system

3.20
test pattern
specified arrangement of spectral reflectance or transmittance characteristics used in measuring an image quality attribute

3.21
test pattern types

3.21.1
bi-tonal patterns
patterns that are spectrally neutral or effectively spectrally neutral, and consist exclusively of two reflectance or transmittance values in a prescribed spatial arrangement

NOTE Bi-tonal patterns are typically used to measure resolving power, limiting resolution and SFR.

3.21.2
grey scale patterns
patterns that are spectrally neutral or effectively spectrally neutral, and consist of a large number of different reflectance or transmittance values in a prescribed spatial arrangement

NOTE Grey scale patterns are typically used to measure opto-electronic conversion functions.

3.21.3
spectral patterns
patterns that are specified by the spatial arrangement of features with differing spectral reflectance or transmittance values

NOTE Spectral patterns are typically used to measure colour reproduction.

4 Test chart

4.1 Representation and recommended size

This clause defines the type and specifications of the test chart depicted in Figure 1. This test chart can be made at various sizes to correspond to popular film sizes. The recommended size is 24 mm × 36 mm, which corresponds to the 35 mm film format.

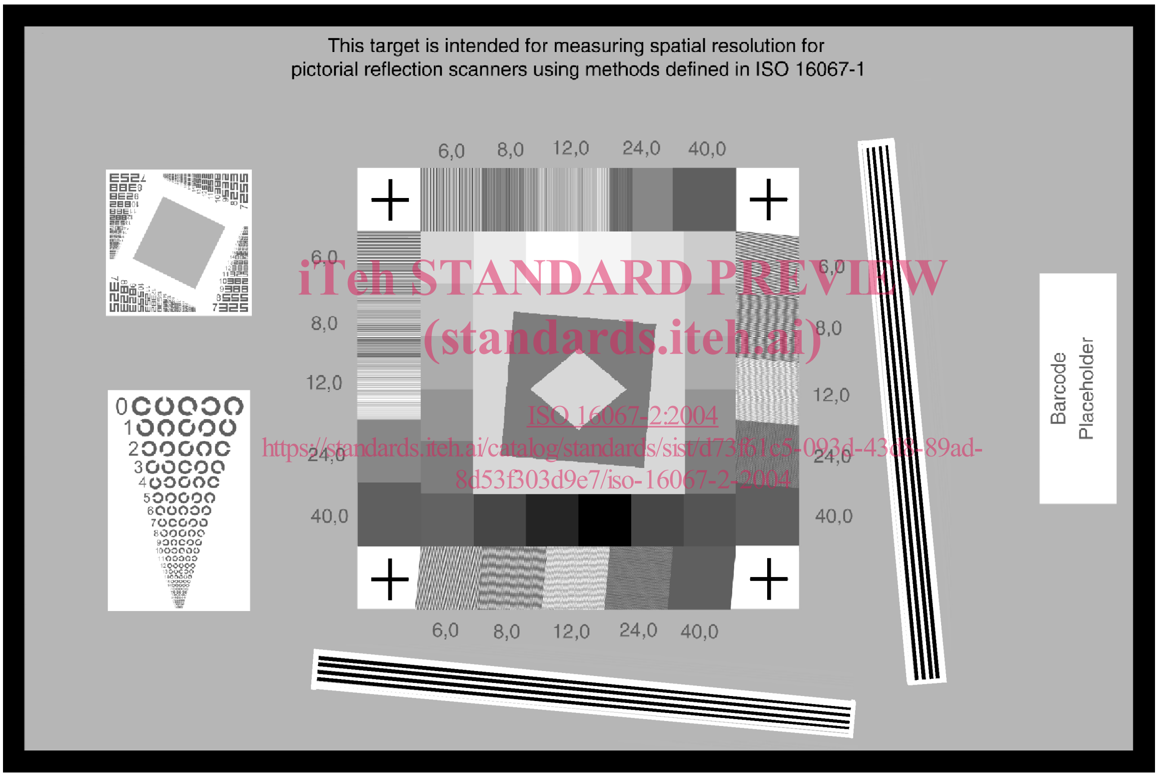


Figure 1 — Representation of the test chart

4.2 General characteristics of the test chart

4.2.1 The test chart shall be a transmission test chart based on a current monochrome photographic film material. The film material shall be spectrally neutral with tolerances as specified in ISO 14524, and resistant to fading.

4.2.2 The active height and width of the reflection test chart should be no less than 16,7 mm. Additional white space may be added to the width or height to include target management data or other test chart elements not defined by this International Standard.

4.2.3 The test chart shall include grey scale patterns and should include bitonal elements. Grey scale patches are necessary to measure the opto-electronic transfer function of the scanner. The bitonal elements may be used to assess limiting visual resolution and aliasing. (See Clause 7.)

4.2.4 The density values of the grey patches shall be in accordance with Annex A. The densities shall be measured as specified in ISO 5-2.

4.2.5 The target manufacturer should state the spatial frequency at which the target's frequency content is 0,2. These declarations should be cited in both cycles per millimetre (cycles/mm) and equivalent dots-per-inch (DPI), where the DPI value equals 50,8 times the spatial frequency in cycles/mm. Suggested wording is, "This target suitable for SFR measurements to XXX cycles per millimetre (xxx dpi)".

The spatial frequency content of the edge features should be the same for both near horizontal, near-vertical, and near-45º edge features, and should be indicated as a graph (Figure 2), or should be characterized with a closed form equation or equations up to the frequency having a 0,2 modulation response.

An example equation corresponding to Figure 2 is the N-th order polynomial:

$$\text{Target Modulation} = C_0 + C_1 \nu^1 + C_2 \nu^2 + C_3 \nu^3 + C_4 \nu^4 + C_5 \nu^5 + C_6 \nu^6 + C_7 \nu^7 \quad (1)$$

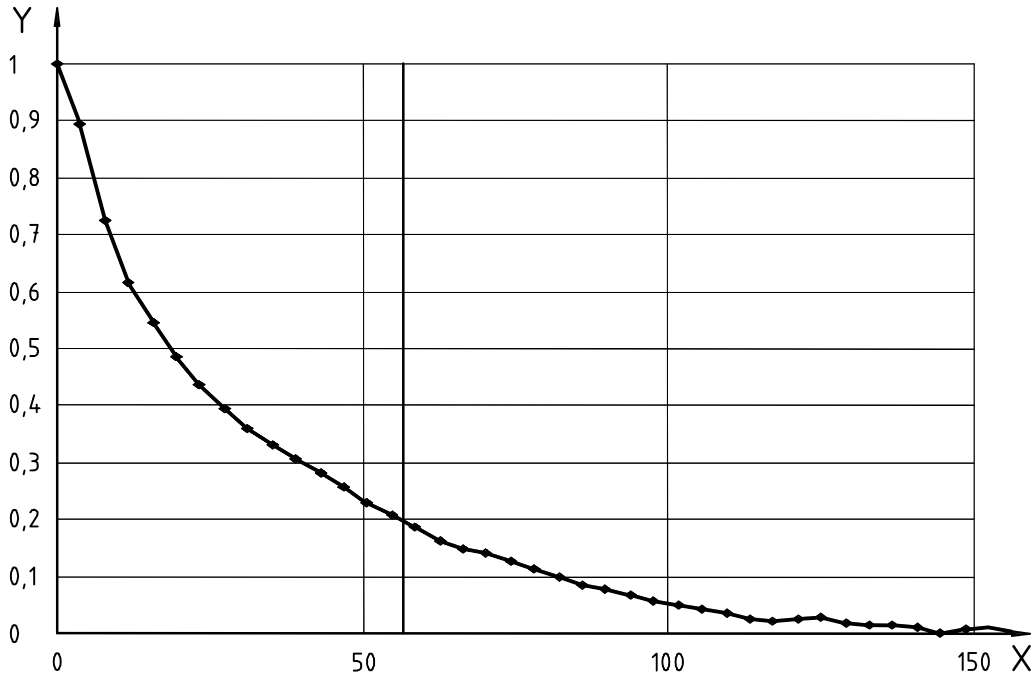
Where ν = spatial frequency in terms of line pairs per millimetre

C_i = polynomial coefficients associated with the i^{th} term

$C_0 = {}_{1,0000e} \times 10^0$ $C_1 = -1,0161e \times 10^{-2}$ $C_2 = -5,9389e \times 10^{-3}$ $C_3 = 5,6116e \times 10^{-4}$

$C_4 = -2,3443e \times 10^{-5}$ $C_5 = 5,0997e \times 10^{-7}$ $C_6 = -5,6120e \times 10^{-9}$ $C_7 = 2,4681e \times 10^{-11}$

The above-mentioned 7th order polynomial is only valid, as an example frequency response characteristic, for spatial frequencies in the range DC to approximately 58,154 1 cycles/mm.



Key

X frequency (cycles/mm)

Y modulation

Figure 2 — Frequency content of a transmission edge's spatial derivative