
Camera shutters — Timing — General definition and mechanical shutter measurements

*Obturbateurs d'appareils photographiques — Durée d'exposition —
Définition générale et mesurages d'obturateur mécanique*

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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*.

This fourth edition cancels and replaces the third edition (ISO 516:1999) which has been technically revised. The following changes have been made:

- The title and scope have been updated to reflect that the document is applicable to mechanical shutters.

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

A superseded edition of this document was developed in the mechanical-shutters-only era. The scope of this edition has been changed as many digital still cameras with non-mechanical shutters are now introduced to the market.

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Camera shutters — Timing — General definition and mechanical shutter measurements

1 Scope

This document provides a uniform basis for determining the exposure times for all types of shutters used in still cameras and contains suitable definitions of the terms used.

It specifies the exposure-time markings for all types of shutters and their tolerances.

The characteristics of all types of mechanical shutters, which are mounted in still cameras and affect the control of exposure, motion-stopping ability and synchronization with a photoflash light source are also defined.

The tolerances specified are the target values for the shutter performance that can be expected to give good results. They are not intended for application as a general inspection standard in controlling the performance of mechanical shutters, since tolerances may vary with the feature and price class of camera tested.

Test methods are described for routine manufacturing testing and quality control. These test methods require access to the focal plane of the camera and can therefore not be applied to assembled digital still cameras.

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

front shutter

any shutter in the vicinity of the lens

Note 1 to entry: The front shutter can be in front of, behind or between the lens elements and can consist of rotating discs, rotating slats, sliding blades, oscillating blades, etc. Programmed shutters are also included.

Note 2 to entry: The common characteristic for the front shutter is that the entire picture area is exposed almost simultaneously.

Note 3 to entry: When the shutter and diaphragm are located too far apart, both exposure and shutter speed may vary at different points in the picture area.

3.2

focal-plane shutter

any shutter in the vicinity of the focal plane

Note 1 to entry: The focal-plane shutter can consist of fixed or variable slit curtains, rotating discs, sliding blades, etc.

Note 2 to entry: The essential feature of the focal-plane shutter is that the picture area is exposed incrementally, in such a way that the time required to expose the entire picture area is greater than the exposure time of any one point.

3.3 effective time

t_e
best measure of the amount of light falling on the picture area

Note 1 to entry: Effective time is defined by the following formula:

$$t_e = \frac{H}{E_0}$$

Note 2 to entry: At any point on the picture area, t_e is generally the same for the entire picture area for front shutters when vignetting is not severe. For focal-plane shutters, t_e will vary with w and v_c . The formula in Note 1 to entry can be approximated with the below formula for convenience in measurement:

$$t_e = \frac{w}{v_c} \text{ (focal plane shutter)}$$

The formula in Note 2 to entry can only be applied under the condition of $w \geq d_s/A$.

3.4 exposure time

t_{e0}
effective time measured at the centre of the picture area

3.5 total time

t_0
the time for which any given point in the picture area is exposed to light

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Application of the picture area exposed to light
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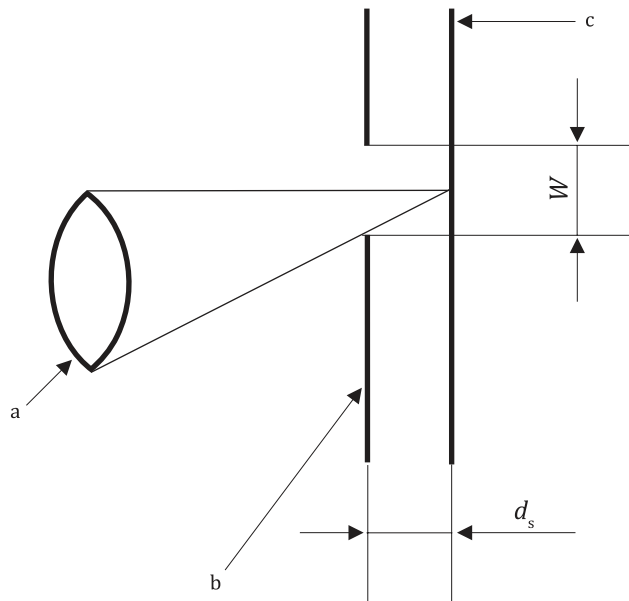
Note 1 to entry: At any point on the picture area, t_0 is generally the same, or almost, on the entire picture area for front shutters.

Note 2 to entry: For a focal-plane shutter, however, t_0 is dependent on w , A , d_s and V_c . The curtain displacement to completely expose one point becomes $w + d_s / A$, which can be converted to t_0 , if the velocity is known, using the following formula:

$$t_0 = \frac{w + \frac{d_s}{A}}{V_c}$$

Note 3 to entry: This formula can be inexact in the presence of vignetting.

See [Figure 1](#).



- a Taking lens.
- b Curtain.
- c Focal lens.

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Figure 1 — Total time for a focal-plane shutter

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3.6 shutter efficiency

η
ratio of effective time to total time

Note 1 to entry: The shutter efficiency is given by:

$$\eta = \frac{t_e}{t_o}$$

3.7 fluctuation of exposure time

p
the value of p is determined by the following formula

$$2^p = \frac{\bar{x} + \sigma}{\bar{x} - \sigma}$$

where x and σ are the mean and standard deviation of the values of five successive measurements

3.8 ratio of two adjacent exposure times

q
ratio of the mean values of two adjacent shutter speed settings obtained from values of five successive measurements

Note 1 to entry: The ratio is expressed by the following formula:

$$2^p = \frac{t_{eo}(n)}{t_{eo}(n+1)}$$

Note 2 to entry: $t_{eo}(n)$ and $t_{eo}(n+1)$ are the exposure times of two adjacent shutter speed settings represented by (n) and $(n+1)$.

3.9 non-uniformity of exposure

r
characteristic which may be found during any single exposure due to lack of coincidence with the principal plane (front shutter) or to variations in curtain velocity or slit width (focal-plane shutters)

Note 1 to entry: Such non-uniformity is expressed as the ratio of the maximum and minimum effective time found by exploring the picture area, and is derived from the following formula:

$$2^r = \frac{t_{e\max}}{t_{e\min}}$$

3.10 overall time

T
elapsed time for exposure of all points in the entire picture area

Note 1 to entry: For front shutters, $T = t_0$.

3.11 photoflash synchronization delay time

t_d
time interval from the initial closing of the shutter synchronization contacts to the moment at which the shutter element moves to the specified position (see 5.2)

Note 1 to entry: For details of ignition circuits of synchronizers, see ISO 10330.

3.12 X contact

synchronization contact for an electronic flash unit

Note 1 to entry: The contact closes while the shutter is fully opened to enable reception of the reflected light from the object through the aperture of the lens or for total illumination of the camera aperture. The X contact can sometimes be used for the M or MF class of photoflash lamp at the slower shutter speeds.

3.13 M contact

synchronization contact for M class of photoflash lamp

3.14 FP contact

synchronization contact for FP class of photoflash lamp

Note 1 to entry: This contact is provided only in the focal plane shutter and can be used for M or MF class of photoflash lamp at the slower shutter speeds.

4 Symbols

- A f-number of the lens
- b exposure time error
- c tolerance for exposure time

<i>d</i>	tolerance for stop
<i>d_s</i>	distance between focal plane and curtain
<i>E₀</i>	maximum illuminance (full open shutter)
<i>E_v</i>	exposure value in units
<i>e</i>	tolerance for exposure meter
<i>f</i>	tolerance for film sensitivity
<i>H</i>	exposure (time-integral of illuminance)
<i>L</i>	film latitude
<i>m</i>	magnification factor
<i>n</i>	positive or negative integer, or zero
<i>p</i>	fluctuation of exposure time, expressed in <i>E_v</i>
<i>q</i>	ratio of two adjacent exposure times, expressed in <i>E_v</i>
<i>r</i>	non-uniformity of exposure, expressed in <i>E_v</i>
<i>s</i>	width of the mask slit in drum tester
<i>T</i>	overall time, in seconds (see Figure 3)
<i>t_c</i>	minimum contact duration, in seconds
<i>t_d</i>	delay time, in seconds (see Figures 2 and 3)
<i>t_E</i>	theoretical exposure time, in seconds [see Formula (1)]
<i>t_e</i>	effective time, in seconds (see Figure A.2)
<i>t_{e0}</i>	exposure time, in seconds (effective time measured at the centre of the picture area)
<i>t₀</i>	total time, in seconds (see Figure A.2)
<i>v_c</i>	average linear velocity of curtain
<i>v_d</i>	linear velocity of rotating drum periphery
<i>w</i>	width of the focal-plane curtain slit
<i>η</i>	shutter efficiency

5 Required characteristics and their tolerances

5.1 Exposure time

Theoretical exposure times that form a series are given, in seconds, by the following formula:

$$t_E = \frac{1}{2^n} \quad (1)$$

Shutters shall be designed to provide exposure times selected from the series below, subject to the tolerances specified in [5.1.2](#).

...8,4,2,1,1/2,1/4,1/8,1/16,1/32,1/64,1/128,1/256,1/512,1/1 024,1/2 048...

NOTE 1 Timing of the shutters need be measured at the appropriate aperture of the lens used (see [Figures 4](#) and [5](#)). In the case of cameras that have interchangeable lenses, the standard lens is used for exposure-time measuring.

NOTE 2 In evaluating shutters without lenses, exposure times are measured under the conditions fixed so as to be equivalent to the requirements of this document.

NOTE 3 A change in *n* by one unit needs a change in time by a factor of 2. This unit is called *E_v* or a step.

5.1.1 Exposure time marking

The exposure-time marking shall be marked as the following rounded-off values of reciprocal numbers of the series specified in [5.1](#). Exposure times longer than 1 s shall not, however, be marked as reciprocal numbers, but should be made evident by colour or some other means of identification.

...8,4,2, 1,2,4,8, 15,30, 60, 125, 250, 500,1 000, 2 000...

The highest marking, however, need not necessarily be selected from this series, but the series beginning with the next lower number should be selected from this series, whenever practicable, and progressing as far as is required in the particular application.

5.1.2 Tolerances

The tolerances of exposure time error, fluctuation of exposure times, ratio of two adjacent exposure times and nonuniformity of exposure should be as shown in [Table 1](#) (see also [7.1](#)). The following [Formula \(2\)](#), in seconds, is applicable to the tolerance of the exposure time:

$$t_{eo} = \frac{1}{2^{(n+b)}} \tag{2}$$

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Table 1 — Tolerances for *b*, *p*, *q* and *r*

Unit: *E_v*

Exposure time	Quantity			
	<i>b</i> ^a	<i>p</i>	<i>q</i>	<i>r</i>
1/125 and longer	±0,3	≤0,3	1 ± 0,45	≤0,2
shorter than 1/125	±0,45	≤0,45	1 ± 0,65	≤0,6

^a The admissible values for individual exposure times are calculated and tabulated in [Annex A](#).

Over the range of -10 °C to 40 °C, the tolerances specified in [Table 1](#) should not be exceeded, with the exception of the tolerance for *b* which may be exceeded by ±0,25 *E_v* over the range of -10 °C to 0 °C. Furthermore, the relative humidity between -10 °C and 0 °C should be not more than 50 % and between 0 °C and 40 °C not more than 80 %.

5.2 Delay time

5.2.1 Front shutters

Delay time and minimum contact duration for synchronization shall be as given in [Table 2](#).