International Standard 516

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Photography — Camera shutters — Timing

Photographie — Obturateurs d'appareils photographiques — Durée d'exposition

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Foreword

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Photography — Camera shutters — Timing

0 Introduction

This International Standard is intended to provide a uniform basis for determining the timing and marking of exposure times of all types of shutters used in still cameras, and to give suitable definitions of the terms used. (See also 6.1.)

1 Scope and field of application

This International Standard defines the characteristics of all types of shutters which are mounted in still cameras and affect the control of exposure, motion-stopping ability and synchronization with a photoflash light source.

It also specifies the exposure-time markings for the shutters and their tolerances.

The tolerances specified are the target values for the shutter performance which can be expected to give good results. They are not intended for application as a general inspection standard in controlling the performance of 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.

2 Reference

ISO 2691, *Photography — Expendable photoflash lamps — Definitions and requirements for luminous flux/time characteristics.*

3 Definitions

For the purpose of this International standard the following definitions apply : (The meanings of symbols used in this clause are given in clause 4.)

3.1 front shutter : Any shutter in the vicinity of the lens. It may be in front of, behind or between the lens elements and may consist of rotating discs, rotating slats, sliding blades, oscillating blades, etc. Programmed shutters are also included.

The common characteristic for the front shutter being that the entire picture area is exposed almost simultaneously. 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. It may consist of fixed or variable slit curtains, rotating discs, sliding blades, etc.

The essential feature for the focal plane shutter being 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 : The best measure of the amount of light falling on the picture area as defined by the following equation :

$$t_e = \frac{H}{E_o} \qquad \ldots (1)$$

t_e at any point on the picture area 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. Equation (1) may be approximated with the following equation for convenience in measurement :

$$t_e = \frac{w}{v_c} \text{ (focal-plane shutter)} \qquad \ldots (2)$$

NOTE — Equation (2) may only be applied under the condition of $w > d_s/A$.

3.4 exposure time, t_{eo} : The effective time measured at the centre of the picture area.

3.5 total time, t_o : The time for which any given point in the picture area is exposed to light.

t_o at any point on the picture area is generally the same, or almost, on the entire picture area for front shutters.

For a focal-plane shutter, however, t_o is dependent on w, A, d_s and v_c. The curtain travel to completely expose one point becomes $w + d_s/A$, which can be converted to t_o if the velocity is known by the following equation :

$$t_o = \frac{w + \frac{d_s}{A}}{v_c} \qquad \ldots (3)$$

NOTE — This equation may be inexact in the presence of vignetting.

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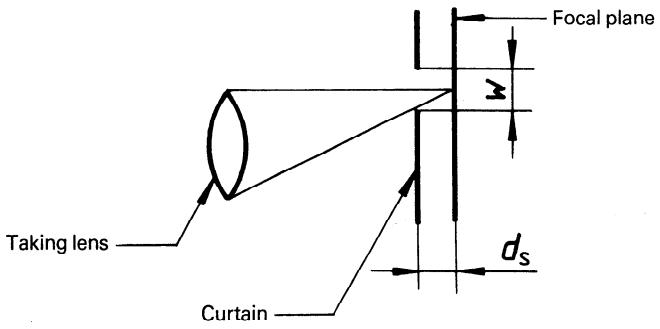

Figure 1 — Focal-plane shutter-total time

3.6 shutter efficiency, η : The ratio of effective time to total time.

$$\eta = \frac{t_e}{t_o} \qquad \ldots(4)$$

3.7 fluctuation of exposure time, p : The value of p is determined by the following equation :

$$2^p = \frac{\bar{x} + \sigma}{\bar{x} - \sigma} \qquad \ldots(5)$$

where $\bar{x}$ and σ are the mean and standard deviation of the values of five successive measurements.

3.8 ratio of two adjacent exposure times, q : The ratio of the mean values of two adjacent shutter speed settings obtained from values of five successive measurements, expressed by the following equation :

$$2^q = \frac{t_{eo}^{(n)}}{t_{eo}^{(n+1)}} \qquad \ldots(6)$$

where $t_{eo}^{(n)}$ 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 : A 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).

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 equation :

$$2^r = \frac{t_e \text{ max.}}{t_e \text{ min.}} \qquad \ldots(7)$$

3.10 overall time, T : The elapsed time for exposure of all points in the entire picture area.

For front shutter T is same as t_o.

3.11 photoflash synchronization delay time, t_d : The 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).

3.12 X contact : Synchronization contact for an electronic flash unit. 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 may sometimes be used for 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. This contact is provided only in the focal plane shutter and may 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

d = tolerance for stop

d_s = distance between focal plane and curtain

E_o = maximum illuminance (full open shutter)

E_v = exposure value in units

e = tolerance for exposure meter

f = tolerance for film sensitivity

H = exposure (time-integral of illuminance)

L = film latitude

m = magnification factor

n = a positive or negative integer or zero

p = fluctuation of exposure time, expressed in E_v

q = ratio of two adjacent exposure times, expressed in E_v

r = non-uniformity of exposure, expressed in E_v

s = width of the mask slit in drum tester

T = overall time in seconds (see figure 3)

t_c = minimum contact duration in seconds

t_d = delay time in seconds (see figures 2 and 3)

t_E = theoretical exposure time in seconds [see equation (8)]

t_e = effective time in seconds (see figure 8)

t_{eo} = exposure time in seconds (effective time measured at the centre of the picture area)

t_o = total time in seconds (see figure 8)

t_s = synchronization contact duration

v_c = average linear velocity of curtain

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v_d = linear velocity of rotating drum periphery

w = width of the focal-plane curtain slit

η = shutter efficiency

5 Required characteristics and their tolerances

5.1 Exposure time

Theoretical exposure times which form a series are given, in seconds, by the following equation :

$$t_E = \frac{1}{2^n} \quad \ldots (8)$$

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, 1/1024, 1/2048 ...

NOTES

1 Timing of the shutters should be measured at the appropriate aperture of the lens used (see figures 4 and 5). In the case of cameras which have interchangeable lenses, the standard lens should be used for exposure-time measuring.

2 In evaluating shutters without lenses, exposure times should be measured under the conditions so fixed as to be equivalent to the requirements of this International Standard.

3 A change in n by one unit requires 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 non-uniformity of exposure should be as shown in table 1 (see also 7.1). The following equation, in seconds, is applicable to the tolerance of the exposure time :

$$t_{eo} = \frac{1}{2^{(n+b)}} \quad \ldots (9)$$

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

Unit : E_v

Quantity / Exposure time	b*	p	q	r
1/125 and longer	± 0,3	0,3 max.	1 ± 0,45	0,2 max.
shorter than 1/125	± 0,45	0,45 max.	1 ± 0,65	0,6 max.

* The admissible values for individual exposure times are calculated and tabulated in the annex.

Over the range of − 10 °C to 40 °C, the tolerances specified above 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 not be 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 follows :

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Table 2 — Delay time of front shutter

Type of contact	Delay time of the synchronization contact		Minimum contact duration t_c (ms)
	t_d (ms)	Remarks	
X	—	Closing of the contacts shall take place between the moment (B) at which the shutter admits 80 % of the light admitted at the maximum aperture of the lens used and the moment (C) which is the halfway point of the fully open time of the shortest exposure time (see figure 2). In spite of the above provision, closing of the contacts may take place after the moment (C) as long as the shutter admits more than 80 % of the light admitted at the maximum aperture of the lens used.	1
M	16 ± 3**	The time lapse from the closing of the contacts (A) to the moment (B) at which the shutter admits 80 % of the light admitted at the maximum aperture of the lens used. (See figure 2.)	2,5

* The contact duration shall be 2,5 ms minimum for those ranges of shutter speeds listed in the instruction manual as suitable for use with any class of photoflash lamps.

** Not applicable to those shutters having a mechanism which changes the delay time in accordance with the exposure time.

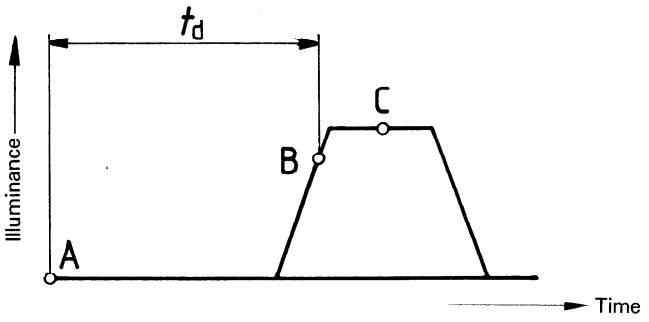
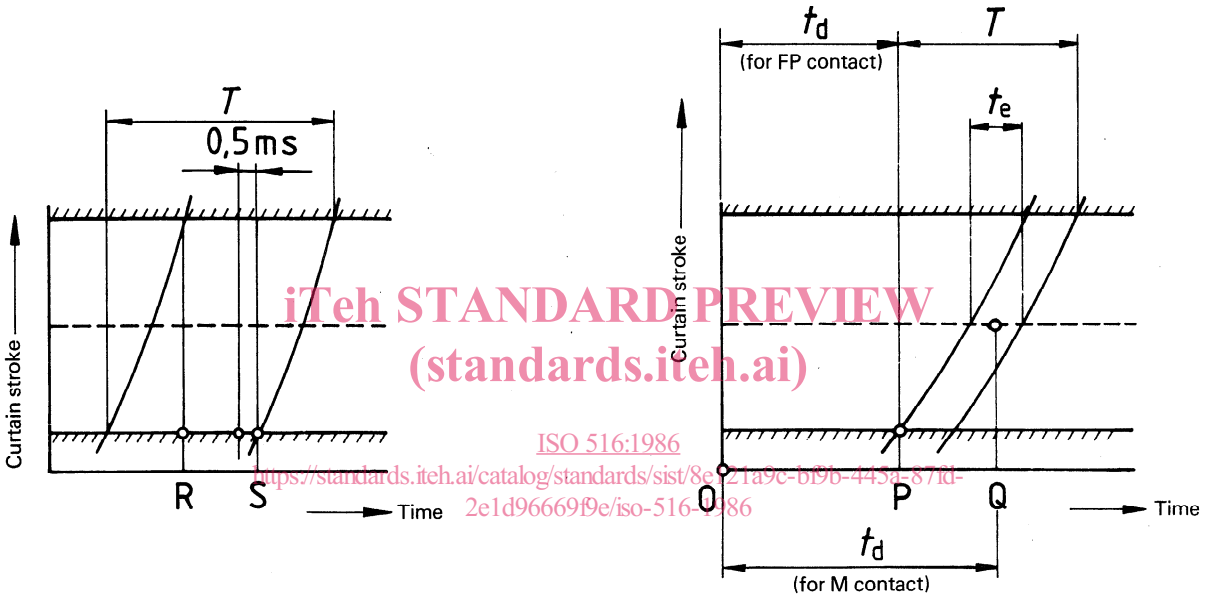


Figure 2 — Front shutter delay time



a) For X-type contact

b) For FP- and M-type contacts

Figure 3 — Focal-plane shutter-delay time

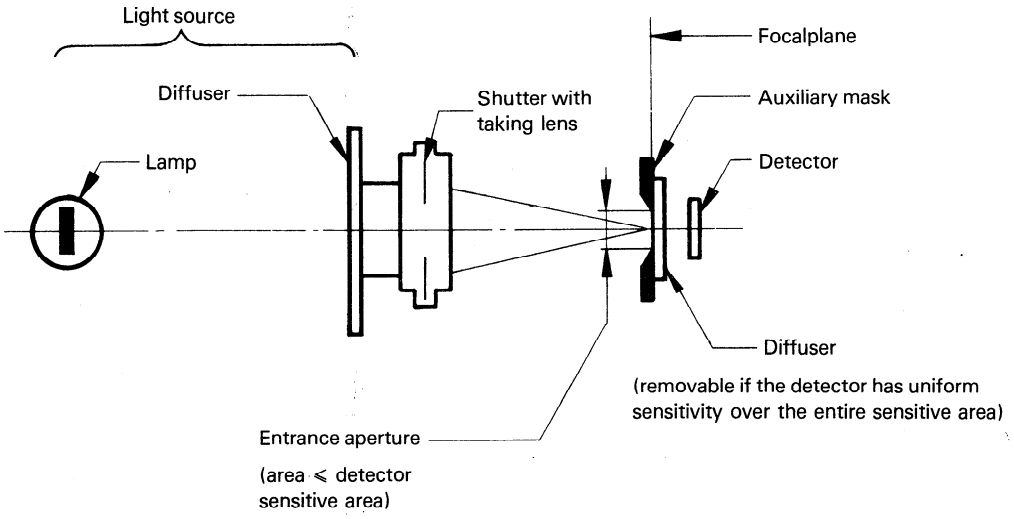


Figure 4 — Test assembly for front shutter timing measurement

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5.2.2 Focal-plane shutters

Delay time and minimum contact duration for synchronization shall be as follows :

Table 3 — Delay time of focal-plane shutter

Type of contact	Delay time of the synchronization contact		Minimum contact duration
	t_d (ms)	Remarks	t_c (ms)
X	—	Closing of contacts shall take place while the shutter is fully opened [after the moment (R) and not later than 0,5 ms before the moment (S) shown in figure 3a)].	1
FP	10^{+5}_{-3}	The time lapse from the closing of the contacts (O) to the moment (P) at which the shutter begins to open [see figure 3b)].	2,5
M**	18 ± 3	The time lapse from the closing of the contacts (O) to the moment (Q) which is one-half of the exposure time at the centre of the picture area (see figure 3b).	

* The contact duration shall be 2,5 ms minimum for those ranges of shutter speeds listed in the instruction manual as suitable for use with any class of photoflash lamps.

** Applicable to those shutters having a mechanism which changes the delay time in accordance with the exposure time and whose overall time is less than the effective duration of a M-class photoflash-lamp (see ISO 2691).

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6 Test methods

6.1 General

The method described for each type of shutter, based on digital readout, is rapid and easy for routine manufacturing testing and quality control. As a rule, this method is applicable only to cases in which the character of the time-illuminance curve of the shutter has been proved consistent and acceptable by such graphic methods as described in the annex.

6.2 Apparatus

6.2.1 Light source

The light source shall consist of a lamp and a diffuser. Luminance at any point on the surface of the diffuser, measured perpendicular to the surface, shall be more than 95 % of the maximum luminance and the fluctuation of luminance shall not exceed ± 5 %. Luminance of the diffuser, measured at any angle to the diffuser up to 60° from the normal, shall not be less than 85 % of the luminance measured perpendicular to the surface.

6.2.2 Detector

The frequency response of the combination of detector, cables and recording equipment shall be within ± 3 dB from D.C. to $100/t_o$: for example for a total time of 1 ms, the frequency response shall be at least 100 kHz (50 % output power, i.e. 70 % output voltage, with sinusoidal input). This combination shall have a linear sensitivity characteristic between 1 % and 100 % of E_o. The sensitive area of the detector shall be large enough to receive all the light passing through the entrance aperture. (See figure 4.)

6.2.3 Time-interval meter

A meter shall have an internal time base, a selection of ranges and an adjustable sensitivity. The frequency of the time base shall be sufficiently high so that at least 100 samples are taken during the minimum effective time to be measured.

6.3 Front shutter test

6.3.1 Test assembly

The test assembly is shown in figure 4. The fully opened standard lens shall be used as a taking lens.

6.3.2 Procedure

Pass a uniform light bundle through the shutter and into the detector (6.2.2) whose output is used to control the time-interval meter (6.2.3). Adjust the sensitivity of the meter to start and stop measurement when the detector output is at the level corresponding to the time (t_o or t_e) being measured as in 6.3.2.1 and 6.3.2.2.

6.3.2.1 Total time, t_o

Adjust the light intensity and meter sensitivity so that gating occurs at 1 ± 0,5 % E_o.

6.3.2.2 Effective time, t_e

Adjust the light intensity and meter sensitivity so that gating occurs at the fraction of E_o which yields a time measurement which is identical to effective time. Determine the fraction as follows :

a) determine t_o and t_e as in clause A.3 of the annex;

b) read the height (E) above the baseline at which the rising and falling positions of the curve are separated by t_e;

c) the height (E) divided by E_o is the fraction of illuminance at which the time measurement is started and stopped.

NOTES

1 If the trace is trapezoidal, t_e can be measured at 0,5 E_o.

2 For front shutters, effective time varies with the aperture of the lens. Therefore the fully opened lens shall be used for the measurement.

3 For programmed shutters effective time shall be measured at the aperture determined by the programming of the shutter.