BS ISO 2721:2013

BSI Standards Publication

Photography — Film-based cameras — Automatic controls of exposure

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National foreword

This British Standard is the UK implementation of ISO 2721:2013.

The UK participation in its preparation was entrusted to Technical Committee CPW/42, Photography.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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INTERNATIONAL STANDARD

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Photography — Film-based cameras — Automatic controls of exposure

Photographie — Appareils de prise de vues à film — Commandes automatiques de l'exposition

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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 2721 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 2721:1982), of which it constitutes a minor revision with the following changes:

a) The title has been updated from “Cameras” to “Film-based cameras”.

b) The scope has been updated to include the clarification, “This standard is not applicable to digital cameras.”

Introduction

This International Standard gives the nominal exposure at the focal plane and its tolerance, which are to be taken as reference values in designing and testing automatic film-based cameras.

"Correct" exposure may vary from one photographer to another due to personal preferences and/or type of photograph. For this reason, no "standard" value for the exposure at the focal plane can be given. However, a "normal" focal plane exposure for a film of a particular speed and an average scene can be determined by allocating representative values to the relevant exposure parameters.

The nominal exposure at the focal plane $H = \frac{H_0}{S}$ or $H = \frac{H_0}{10^{(S^0 - 1)/10}}$ given in this International Standard is determined on the above assumption. Long experience has proved that the above value is adequate for most automatic cameras in most situations.

Since with some cameras the use of a different focal plane exposure gives better results when taking pictures outdoors, the nominal focal plane exposure is only to be considered as a reference value. The tolerance ± 1 step (±1 Ev) is also a reference value. Experience has proved that this tolerance is satisfactory in most cases. However, a much tighter tolerance, such as ± 1/3 step, is often required by advanced photographers for film such as colour reversal film having limited exposure latitude.

On the other hand, if colour reversal films are not likely to be used in certain kinds of cameras, as in the case of cameras using 110 size colour negative films, even an exposure deviation of + 3 steps or – 1 step is acceptable for such cameras.

Therefore, when testing and/or evaluating an automatic camera according to the methods specified in this International Standard, the above-mentioned points must be taken into consideration. A photographic check of the correct exposure is recommended.

Photography — Film-based cameras — Automatic controls of exposure

1 Scope

This International Standard specifies the exposure at the focal plane of film-based cameras for values of two exposure parameters, i.e. field luminance and film speed, and also describes methods of evaluating other photometric characteristics, such as the acceptance angles of the photoelectric system.

This International Standard applies to automatic exposure control systems which are built into film-based cameras or coupled with them to regulate the exposure in the focal plane as a function of the several exposure parameters. The mechanism can control either the focal-plane illuminance or the exposure-time interval or both. Pointer (or needle) matching systems are included in this International Standard even though they are not fully automatic. This standard is not applicable to digital cameras.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-6, *Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
exposure in the focal plane
denoted by *H*[1)] and defined by the equation

$$H = \frac{1}{A} \int_A \int_{t_1}^{t_2} E(r,t)\, \mathrm{d}t\, \mathrm{d}r$$

where

A	is the prescribed area for the exposure measurement;
t_1	is the time at which the exposure time begins;
t_2	is the time at which the exposure finishes;
$E(r,t)$	is the illuminance in the focal plane at a point (coordinate r) in the prescribed area at an instant t during the exposure time.

1) International Lighting Vocabulary. Publication CIE 17,1970: light exposure *H*. In this International Standard, *H* is referred to as “exposure”.

3.2
automatic setting of camera exposure
action of the automatic exposure control intended to maintain substantially constant exposure at the focal plane for a preset film speed for all values of field luminance within the exposure capabilities of the camera

Note 1 to entry: The film speed setting may be made manually or may be automatically sensed from the film or its container.

Note 2 to entry: Operation of the control may require the operator's participation in adjusting an indicator to a fiducial point or condition for set-point recognition, but should not require him to read light value indications and transfer the information to another mechanism having similar fiducial markings.

3.3
exposure capability of camera
difference between the maximum exposure value for which the camera can provide nominal focal-plane exposure and the minimum exposure value for which the camera can provide nominal focal-plane exposure, both for the film speed ISO 100/21°

Note 1 to entry: When describing the exposure capability of a camera, the film speed should be indicated.

4 Specific requirements

4.1 Scales

If the camera has scales for f-number, exposure time, exposure value, or film speed, the numerical values according to ISO 2720 shall be applied.

4.2 Out-of-range indication

For cameras designed to use colour reversal films, automatic indication, for example by an optical signal in the viewfinder, should be displayed when the field luminance exceeds the exposure capability of the camera by more than 1 E_V (1 exposure value = 1 step) in either over-exposure or under-exposure. This indication need only be provided if the exposure capability of the camera does not cover subject luminance below 4 cd/m^2 and above 4096 cd/m^2. Tests are made with a uniform source.

In addition, a long exposure signal should be provided to indicate when the field luminance is such as to result in an exposure longer than approximately 1/30 s. This signal need not be provided if the camera cannot give an exposure longer than 1/30 s without the photographer being aware of it.

4.3 The sensors of exposure controls

4.3.1 Spectral sensitivity

The spectral sensitivity of the system response in the camera shall manifest no discontinuities within the visible spectrum (380 nm to 780 nm).

4.3.2 Spectral sensitivity tests

For cameras designed to be used in daylight, tungsten light, and with other artificial sources, the ratio of the responses of the light sensors including optical systems to field luminances of distribution temperature 2856 K compared with those at 4700 K shall be $1{,}0^{+\,0{,}26}_{-\,0{,}21}$ (corresponding to ± 1/3 E_V). Not more than 10 % of the total response of the light sensors, including optical systems, should be due to wavelengths longer than 700 nm when the sensors are exposed to a light source of equal energy at all wavelengths. Not more than 10 % of the total response of the sensors should be due to wavelengths shorter than 380 nm when tested in the same manner.

5 Calibration of the exposure controls

5.1 Method of calibration

In this International Standard, the word calibration means the adjustment of the exposure control mechanism so that the measured focal-plane exposure is within the limits described in this International Standard.

The exposure controls of the camera shall be calibrated by actual measurement of the exposure in the focal plane. The exposure shall be measured within a circular area in the focal plane, which is concentric with the lens axis, and of diameter equal to three-quarters of the shorter side of the nominal picture format of the camera. A circular area, whose diameter is smaller than three-quarters of the shorter side of the nominal picture format, may be used for medium and large format cameras.

The exposure is measured by placing a device in the focal plane having a circular aperture of the diameter described above, located in the exact plane of focus of the lens, when the latter is adjusted to focus at a distance of 5 m or more. If a smaller aperture is used, the influence of the size of the measuring area shall be taken into account as in the example of Annex B.

The sensor used for calibration shall have, for cameras having sensors as described in 4.3.2, a photopic response in accord with the spectral luminous efficiency for the CIE standard photometric observer $V(\lambda)$ (see International Lighting Vocabulary, CIE Publication No. 17, 1970) or a correlatable spectral sensitivity.

The sensor shall be large enough to receive all of the flux transmitted by the circular aperture of the measuring device.

For methods of measuring the exposure in the focal plane, see Annex A.

5.2 Light source for calibration

The light source used for calibration of the exposure control shall approximate a uniformly diffusing (Lambertian) surface source that subtends a field angle at least 25 % larger in diameter than the photometric field of the exposure control and of the measuring device in the focal plane. The source shall provide a continuous spectrum throughout the visible range, and shall be uniform in luminance within ± 4 %. The distribution temperature shall be (4 700 ± 200) K. The spectral radiance shall not vary by more than $^{+0,26}_{-0,21}$ % from that of a full radiator of 4 700 K at wavelengths from 420 to 1 050 nm.

The luminance of the source at an angle of 60° from the optical axis shall be at least 85 % of that on the optical axis; each measurement being made in an area around the same point of the source.

The range of luminance of the calibration source should be adjustable over the range of the exposure capability of the camera plus the over-range indication increments if applicable.

5.3 General test conditions

The camera shall be calibrated with the optical axis horizontal or in the position of normal use if designed for special purposes.

The ambient temperature shall be (23 ± 3) °C and relative humidity of (65 ± 20) %.

Stray light, such as reflections from the camera, shall be eliminated.

If adjustment of the camera parts is required to obtain the exposure setting, the set point should be approached from both directions to determine the "hysteresis" or lost motion in the mechanism. Readings may be taken for both conditions and the average value used in computing the calibration accuracy. The amount of the "hysteresis" shall also be stated.

When the field luminance is changed, a time interval of at least 3 s may be allowed before the exposure setting is made or measured.

5.4 Exposure in the focal plane

The nominal exposure H in the focal plane for a film of ISO speed S (arithmetic) or $S°$ (logarithmic) and with a luminance range of from 4 to 4 096 cd/m^2 (corresponding approximatively to exposure values E_V = 5 to E_V = 15 for ISO 100/21° film) should be: $H = \frac{H_0}{S}$ or $H = \frac{H_0}{10^{(S^0 - 1)/10}}$ with the constant H_0 = 10 Ix · s.

The nominal exposure may have other values for certain special cameras; in this case, the nominal aim value shall be stated on the camera or in the instruction booklet or in the service manual.

The nominal exposure in the focal plane may be increased to 1,26 times the amount (corresponding to 1/3 E_V) for 8 mm and Super 8 cine-cameras.

For cameras designed to use colour reversal films, the measured value of the exposure in the focal plane of a camera shall not differ from the nominal or the indicated value H by more than the difference which corresponds to 1 $E_{V,}$ i.e. it shall lie between 0,5 H and 2 H (manufacturing tolerance).

6 Acceptance angles of the photoelectric system

The sensitivity of the photoelectric system depends on the direction of incidence of light. This directional dependence is described by the size of the acceptance angles in different directions.

6.1 Specific acceptance angle

For infinity objects, specific acceptance angles are the angles subtended at the centre of the camera lens between the camera lens axis and the directions at which the sensitivity to light of the light receptor is reduced to one half of its maximum value.

6.2 Oblique acceptance angles

Oblique acceptance angles are the angles subtended at the centre of the camera lens between the camera lens axis and the directions at which the sensitivity to light of the light receptor is reduced to one sixteenth of its maximum value.

NOTE Specific and oblique acceptance angles are defined by the direction of measurement with respect to the lens axis, “left”, “right”, “up”, or “down”. The acceptance angle is denoted “up” when the light source is above the lens axis of the camera, etc.

Annex A
(normative)

Measurement of light exposure in the focal plane and calibration of measuring instrument

A.1 Measurement of light exposure in the focal plane

Exposure may be measured directly by a photoelectric detector connected with an integrating circuit or by an oscilloscope method. For cine-cameras, it is mainly determined by the measurement of the time-averaged focal plane illuminance. If it is possible to hold the shutter open, exposure may be determined by measurement of the focal plane illuminance and the exposure time.

A.1.1 Exposure measurements

A light-sensitive device as in 5.1 having very low dark current and a linear response to light should be used.

The device should be connected to a suitable measuring instrument with which it has previously been calibrated for the source used and placed either in the focal plane of the camera or in a position from which the focal plane illuminance can be determined. The camera lens and light receptor should be presented to the light source described in 5.2. The output of the light-sensitive device may be integrated with respect to time to determine exposure by one of the following methods.

A.1.1.1 Capacitor method

The charge upon a capacitor is equal to the integral with respect to time of the current flowing into it and is proportional to the voltage across it. If the current is produced by a light-sensitive device with linear light response, the charge is proportional to the integral with respect to time of the illuminance on the light-sensitive device; this is exposure and an instrument used to measure the voltage across the capacitor can be calibrated in terms of the exposure to which the light-sensitive device is subjected. The calibration method is described in A.2.

In the capacitor method, the output photocurrent of the light-sensitive device is used to charge a capacitor and a very high impedance voltmeter is used to measure the resulting voltage across it. This voltage is a measure of the exposure.

A.1.1.2 Oscilloscope method

The voltage derived linearly from the photocurrent output of the light-sensitive device should be applied to an oscilloscope which has a high degree of linearity with respect to voltage in the vertical deflection and the frequency bandwidth of the Y deflection amplifier of which is sufficient to avoid any distortion of the input signal.

Calibration of the exposure measuring devices may be carried out as described in A.2.

A.1.1.3 Exposure determination by the average focal plane illuminance method for a cine-camera

For a cine-camera, the quotient of the average focal plane illuminance of intermittent exposure (E, in lux) and the frame rate (n, in frames per second) is equal to the exposure per frame (H, in lux seconds):

$$H = \frac{E}{n}$$

A light-sensitive device with a sufficiently high time constant should be used. The relationship between the illumination on the light-sensitive device and its electrical output should be measured by mounting it on a photometer bench and measuring its output when its distance from a standard lamp is varied. The time response of the device should be measured by mounting it behind a light-interrupting disc providing a constant ratio of period of light "on" period of light "off", and verifying that the average cell output when the input illumination is constant is independent of the speed of the disc over the range of speed corresponding to the shutter speed of the camera to be tested.

The light-sensitive device should then be mounted in the focal plane of the camera, which is subjected to a constant illumination, its shutter operated at its nominal frame rate, and the output of the light-sensitive device measured. The illumination corresponding to this output, divided by the frame rate per second, gives the exposure per frame.

A.1.2 Focal plane illuminance measurement

Focal plane illuminance may be measured when it is possible to hold the shutter open without interfering with the automatic control of the aperture. A light-sensitive device as in A. 1.1 should be used. The camera lens and light receptor should be presented to the light source specified in 5.2. Focal plane illuminance should be converted to exposure by multiplying by the effective exposure time. Exposure time should be measured.

On cameras where the shutter efficiency is not high, the variation of the effective exposure time with change of aperture will be significant. Allowance for this effect should be made by making measurements at the most frequently used aperture and shutter speed setting.

Calibration of the illuminance measuring device may be carried out by illumination with a lamp of known luminous intensity and calculation of the illuminance by applying the inverse square law of illuminance (see A.2.2).

A.2 Calibration of the exposure measuring instrument

The exposure in the focal plane is measured by means of a photoelectric detector as in 5.1. A diffusing screen (pot opal glass) or the opening of an integrating sphere is put before the photocathode of the detector as area of receptor.

A.2.1 The calibration may be carried out as follows (see Figure A.1): the integrating capacitor should be shunted by a resistor. The exposure scale H shall then be calibrated by giving illuminance E at the opening of the light receptor of the instrument; the relation between exposure and illuminance is obtained by the following equation:

$$H = ECR$$

where

H is the exposure scale, in lux seconds;

E is the illuminance at the opening of the light receptor, in lux;

C is the capacitance, in farads;

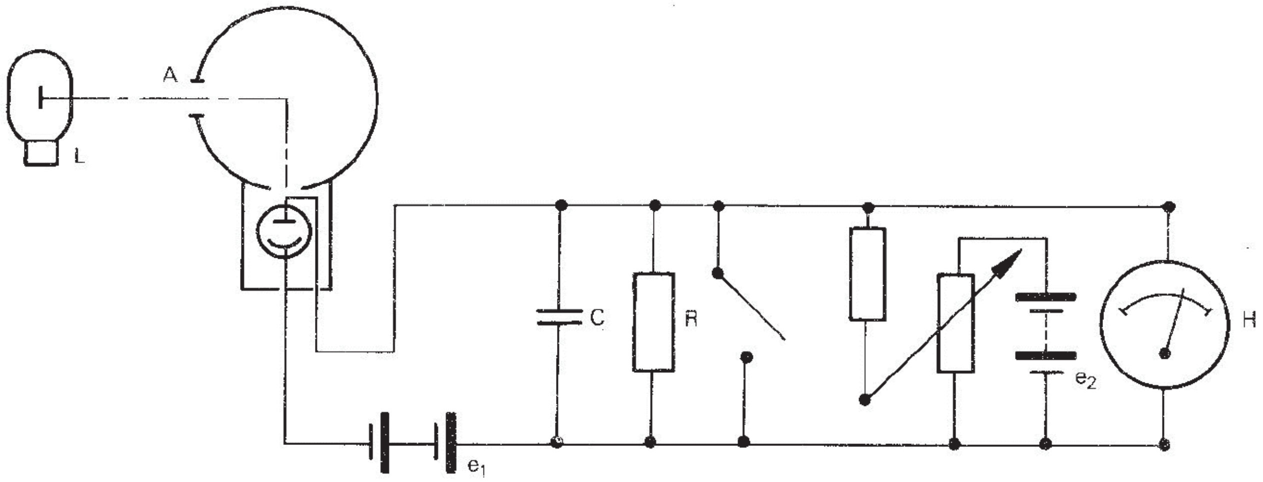
R is the resistance, in ohms.

The calibration light source shall be a lamp of known luminous intensity I. Illuminance shall be calculated by the inverse square law of illuminance (see A.2.2). Capacitance and resistance shall previously be measured with an uncertainty within ± 1,5 %.

A.2.2 Exposures of a known quantity $H = E \times t$ for the calibration can also be obtained by combining a lamp having the luminous intensity I with a shutter having the open time t. The illuminance E of the area of receptor of the measuring device, in the case of normal incidence of light, is calculated from I and the distance r of the lamp from the area of receptor by use of the formula:

$$E = \frac{I \times \Omega_0}{r^2}$$

where Ω_0 is the unit solid angle.



Key

L lamp operated at 2 856 K

A opening of the light receptor

C integrating capacitor

R resistor for the calibration of the instrument

e_1 power supply for the photoelectric detector

e_2 power supply for dark current compensation

H focal plane exposure measuring device

Figure A.1 — Circuit diagram for calibration

Annex B
(normative)

Size of measuring area

The illuminance in the focal plane of a camera diminishes from the centre to the border of the image field by vignetting and by the decrease with $\cos^4$ of the angle θ of image points off the optical axis. Vignetting, i.e. shadowing out of the image borders by the lens mounting, depends on the aperture and on the type of lens. It vanishes for small apertures and cannot be described generally.

However, the influence of the $\cos^4$ decrease can be calculated. Table B.1 gives, for a lens of 50 mm focal length and an image area 24 mm × 36 mm, the percentage increase or decrease of measured illuminance in the focal plane when the diameter of the measuring area deviates from the value stipulated in 5.1 (three-quarters of the shorter side of the nominal picture format = 3/4 × 24 = 18 mm). The deviations of the measured values for small *d*-values exceed by only a small amount the measuring uncertainty (approximately ± 2 %).

Table B.1 — Deviations of measured illuminance in the focal plane with variations in diameter *d* of the measuring area for focal length *f* = 50 mm and image area 24 mm × 36 mm

Diameter, *d*	Deviations of illuminance
mm	%
2	+ 3,2
4	+ 3,1
6	+ 2,9
8	+ 2,6
10	+ 2,2
12	+ 1,8
14	+ 1,2
16	+ 0,7
18	± 0
20	- 0,7
22	- 1,5
24	- 2,4

Annex C
(normative)

Performance test

C.1 Battery conditions

Unless a battery condition indicator is provided on an electric drive camera where the power for the automatic exposure control system is obtained from the same batteries as are used for driving the camera, the minimum voltage at which the control system operates satisfactorily should be no higher than the minimum voltage required to drive the camera. If a separate battery is used to supply power to the automatic exposure system and no means is provided to indicate when the battery is failing, the instructions supplied with or on the camera should give some guidance on the expected battery life.

If the battery life is liable to be shortened by leaving the camera exposed to light when not in use, a warning to this effect should be included.

C.2 Effect of electrostatic charge

The effect of electrostatic charge should be expressed in terms of the change in exposure error found 1 min after an electrostatic charge has been applied to any external part of the camera by rubbing with whatever material induces the greatest charge.

The camera should be conditioned at a relative humidity of 20 % or less for a period of 8 h before the test, which should be carried out at this relative humidity.

C.3 Shock resistance

Shock resistance should be expressed in terms of the changes in exposure error, friction, and balance errors after the system has been subjected to one impact of half-sine wave-form of peak acceleration 75 g and duration 3,5 ms, in accordance with IEC 60068-2-27, test Ea, on each of its six sides (a total of six impacts). Other test conditions may be applied if they represent an equivalent or more severe test.

C.4 Effect of vibration

The effect of vibration should be expressed in terms of the changes in exposure error, friction, and balance errors which occur after the control system has been subjected to vibration in accordance with IEC 60068-2-6, test Fc, applied in the following manner.

The system should be vibrated successively in three mutually perpendicular directions, one of which is parallel with the pivot axis of the meter. The frequency should be changed at a uniform rate from 30 Hz to 100 Hz to 30 Hz in 5 min. The vibration should be applied for 20 min in each of the three directions. The total peak-to-peak amplitude should be adjusted to give a maximum acceleration of 2 g. Other test conditions may be applied if they represent an equivalent or more severe test.

C.5 Effect of extreme storage temperature cycle

The effect of extreme storage temperature cycle (− 30 ± 3) °C and (+ 50 ± 3) °C should be expressed in terms of the change in exposure error from that before the test, at any point within the nominal range of control.

The system should be subjected to each prescribed temperature for at least 24 h.

Measurements of exposure error should be taken after the system has been maintained for a period of at least 2 h, both before and after the test, at a temperature of (23 ± 3) °C and relative humidity of (65 ± 20) %.

C.6 Effect of humidity

The effect of humidity should be expressed in terms of the change in exposure error from that before the test at any point within the nominal range of control, after the system has been subjected to relative humidity of (90 ± 5) % at (23 ± 3) °C for 48 h.

Measurements of exposure error should be taken after the system has been maintained for a period of at least 2 h, both before and after the test, at a temperature of (23 ± 3) °C and relative humidity of (65 ± 20) %.

C.7 Fatigue of the photocell

Fatigue of the photocell should be expressed in terms of the change in exposure error after the control system has been subjected to the following treatment.

The system should be stored in the dark for at least 24 h and then suddenly exposed to a light source with a distribution temperature of between 2 650 K and 2 900 K at a field luminance of 2 048 cd/m^2. The exposure error should be determined after 5 s and after 3 min or any further period not exceeding 1 h provided that the fatigue measured is not thereby reduced.

C.8 Response time

The response time should be measured by exposing the control system to a luminance of 256 cd/m^2 for at least 1 h and then suddenly exposing it to a luminance of 2 048 cd/m^2. The time for the measured exposure to arrive at and remain within 1/3 step of that indicated at the end of 15 s is the response time.

C.9 Recommended luminance test levels

The exposure should be specified at the following preferred luminance levels to facilitate ease of testing and intercomparison. The recommended test levels are 4, 64, 256, 2 048, and 4 096 cd/m^2. These test levels are in addition to test levels that might be required by design characteristics of the camera.

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