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Photographic lenses — Methods for
the measurement of the effective
aperture, F-number and relative
aperture

ICS 37.040.10

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measurement

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. JIS B 7095:1978 is replaced with this JIS B 7095:1997.

This Standard contains Annexes as under;

Annex 1 (informative) Measuring methods of T-number

Annex 2 (informative) Measuring methods of effective F-number

Annex 3 (informative) Measuring methods of effective T-number

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Photographic lenses—Methods for the measurement of the effective aperture, F-number and relative aperture

Introduction This Japanese Industrial Standard is based on **ISO 517**, *Photography—Apertures and related properties pertaining to photographic lenses—Designations and measurements* published in 1996 as the 2nd edition without changing the technical contents as for the corresponding parts. The items (measuring methods of T-number, measuring methods of effective F-number and measuring methods of effective T-number) not specified in the corresponding International Standard are added as the Annex (informative) to this Japanese Industrial Standard.

In Japanese Industrial Standards, the provisions of **ISO 517** are divided into three standards of **JIS B 7094**, **JIS B 7095** and **JIS B 7106**.

1 Scope This Japanese Industrial Standard specifies the measuring methods of effective aperture, F-number and relative aperture of photographic lenses.

Remarks 1 In **ISO 517**, “f-number” is used, but in this Japanese Industrial Standard F-number is used in accordance with the conventional custom and present state in the industries.

2 The F-number and T-number which are effective when the lens is used in a finite object distance are called effective F-number and effective T-number respectively. For T-number, effective F-number and effective T-number, Annex 1, Annex 2 and Annex 3 are provided respectively.

3 The following is the corresponding International Standard to this Standard:

ISO 517:1996 *Photography—Apertures and related properties pertaining to photographic lenses—Designations and measurements*

2 Normative references The following standards contain the provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards indicated below shall be applied.

JIS B 7094 *Methods of measurement for focal length of photographic lenses*

JIS Z 8120 *Glossary of optical terms*

3 Definitions For the purpose of this Standard, the definitions given in **JIS Z 8120** and the following definitions apply.

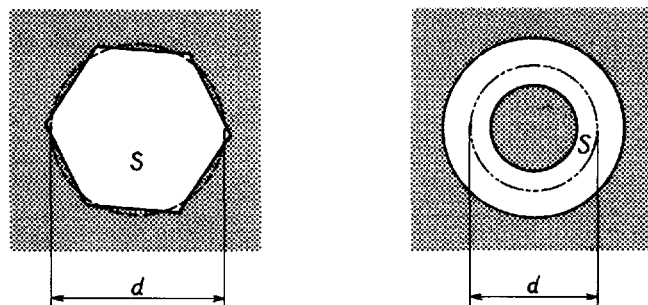
- a) **aperture stop** Physical stop that limits the cross-section of the light beam that can pass through the lens to reach the center of the on-axis image.
- b) **entrance pupil** Image of the aperture stop as viewed from a point in the object space on its optical axis (the image of the aperture stop formed by the front elements of the lens).
- c) **exit pupil** Image of the aperture stop as viewed from a point in the image plane of the lens and on its optical axis (the image of the aperture stop formed by the rear elements of the lens).
- d) **effective aperture** Diameter of the circle having an equal area to the cross-section perpendicular to the optical axis of the parallel beam which comes from the object point at the infinity on the optical axis of the lens and passes through the lens having an aperture equivalent to a given diaphragm scale.

Remarks: The effective aperture of lens is expressed by the formula (1) (see Fig. 1).

$$d = 2\sqrt{\frac{S}{\pi}} = 1.13\sqrt{S} \dots\dots\dots (1)$$

where, d : effective aperture (mm)

S : sectional area of the parallel beam (mm²)



(a) For a non-circular aperture (b) For an annular aperture

Fig. 1 Effective aperture

- e) **F-number** The ratio of the focal length of the lens to the effective aperture.

Remarks: The F-number of the lens is expressed by the formula (2).

$$F = \frac{f}{d} \dots\dots\dots (2)$$

where, F : F-number

f : focal length (mm)

d : effective aperture (mm)

- f) **relative aperture** The inverse number of the F-number.

Remarks 1 This shall be expressed as given in the following, using the F-number (F).

$$1 : F$$

- 2 In ISO 517, the relative aperture is defined first and the F-number is defined by this. That is the technical contents are the same because of the writing only in reverse order.

4 Measuring methods of effective aperture

4.1 Types of measuring methods The measuring methods shall be the following 3 types. If the same result can be obtained, other method may be used.

- a) Measuring method 1 (method to measure directly the diameter of entrance pupil)
- b) Measuring method 2 (method by means of the telecentric-projection optical system)
- c) Measuring method 3 (method by means of the pinhole on the focal plane)

4.2 Measuring conditions The measuring conditions shall be as given in the following:

- a) The photographing distance scale of the lens to be tested shall be adjusted to the infinity.
- b) The diameter of the pinhole to be used in measurement shall be $\frac{1}{150}$ or under the focal length of the lens to be tested, and should preferably be smaller as far as possible.
- c) The projecting lens of the telecentric-projection optical system to be used in measurement shall be sufficiently larger than the aperture of the lens to be tested in its aperture, as well as be provided with a diaphragm (telecentric diaphragm) on the focal plane of its screen side.
- d) The telecentric-projection optical system to be used in measurement shall have been sufficiently corrected to aberrations, particularly to distorsional aberration and the spherical aberration of pupil.
- e) In the measurement, the area of the aperture or aperture image to be projected on the screen shall necessarily be obtained by $\pm 2\%$ in relative error.
- f) In the lens and the like whose purposes are to obtain magnified images, the sides designated in respective lenses shall be considered to be objective sides, in measurement.
- g) The microscope to be used in measurement shall have a mechanism possible to shift whole range of the entrance pupil of the lens to be tested, in a direction at right angle to the optical axis, having a working distance sufficiently long to permit

the microscope to be focused on the opening of the lens to be tested from the object side and being fitted with a reticle.

4.3 Measuring method 1 (method to measure directly the diameter of entrance pupil)

The procedure of the measurement shall be as follows:

- a) Place a microscope in front of the extended light source and place the test lens between the extended light source and the microscope. In this case, the posture of the lens to be tested shall be adjusted so that its image side faces to the extended light source and the optical axis becomes parallel to the optical axis of the microscope.
- b) Focus the microscope upon the edge of the opening with the smallest apparent image.
- c) The microscope is traversed. By measuring its displacement, determine the diameter of the entrance pupil.

Remarks : If the opening of the lens (diaphragm or edge of the lens) is not circular, the diameter of a circle with the same area as the entrance pupil of the lens to be tested shall be the effective aperture.

4.4 Measuring method 2 (method by means of the telecentric-projection optical system) The procedure of the measurement shall be in accordance with the following (see Fig. 2):

- a) Arrange the telecentric-projection optical system (consisting of a projection lens, telecentric diaphragm and screen. Hereafter referred to as "projection system") confronting to a extended light source, and place a lens to be tested between the extended light source and the projection lens. In this case, direct the posture of the lens to be tested so that its optical axis becomes parallel to the optical axis of the projection system, facing its image side to the extended light source.
- b) By travelling the lens to be tested along the optical axis of the projection system, measure the area of the aperture image on the screen, at the position where the image of the full circumference of the entrance pupil of the lens to be tested becomes clearest. In this case, the telecentric diaphragm shall have been adjusted to such a size that the image of the full circumference of the entrance pupil of the lens to be tested can be obtained sufficiently clearly.
- c) By projecting its image on the screen similarly to b), using an object of known size instead of the lens to be tested, calibrate the projecting magnification of the projection system. However, it should be preferable to use an object whose size is similar to the effective aperture of the lens to be tested as far as possible, and the size of the telecentric diaphragm shall be kept as in the condition of b).
- d) Express the effective aperture of the lens to be tested by formula (3), using the area of the aperture image on the screen given in b) and the projecting magnification of the projection system given in c).

$$d = \frac{2}{M} \sqrt{\frac{S'}{\pi}} = \frac{1.13}{M} \sqrt{S'} \dots\dots\dots (3)$$

where, d : effective aperture (mm)

S' : area of the aperture image (mm²)

M : projecting magnification of the projection system

Remarks : In the case where the shape of the aperture of the lens (diaphragm or rim of lens) is of a circle or similar enough to a circle, the effective aperture may also be calculated from the formula (4), without measuring the area of the aperture image, measuring its diameter or mean diameter and using the projecting magnification of the projection system. In this case, the measuring relative error of the diameter or mean diameter shall be $\pm 1\%$.

$$d = \frac{d'}{M} \dots\dots\dots (4)$$

where, d : effective aperture (mm)

d' : diameter or mean diameter (mm)

M : projecting magnification of the projection system

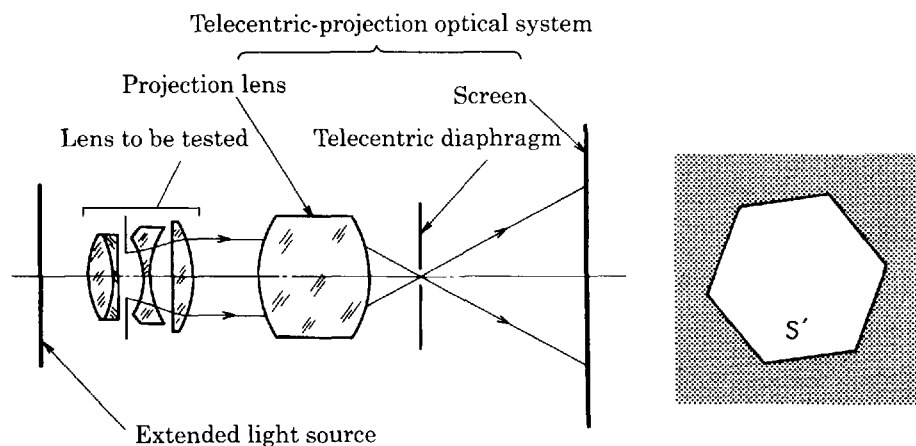


Fig. 2 Measuring method 2 of effective aperture

4.5 Measuring method 3 (method by means of the pinhole on the focal plane) The procedure of the measurement shall be in accordance with the following (see Fig. 3):

- Place a pinhole on the focal plane of the lens to be tested, and allow its position to coincide with the focal point.
- Illuminate the pinhole from the opposite side of the lens to be tested, allow the pencil of rays which has passed through the pinhole to fill the aperture of the lens to be tested sufficiently.