

An Interpretation of Current Exposure Meter Technology

ALLEN STIMSON,* *Apparatus and Optical Division, Eastman Kodak Company, Rochester, N.Y.*

This paper attempts to interpret the changes that have taken place in the past year in exposure meter technology. The 1961 revision of the American Standard for Photographic Exposure Meters¹ includes the first complete array of the new exposure nomenclature, the Additive System. Among other innovations, meters will henceforth be calibrated at 4700°K. instead of 2700°K to make them more accurate in daylight and eliminate the need of different tungsten speeds for most panchromatic materials. This standard not only covers its field thoroughly but prescribes methods of measurement and includes more background technology and educational material than most documents of this character. The ASA subcommittee for exposure meters has kept the standard up-to-date and has agreed on desirable uniform procedures in advance of actual factory practice.

The principal consumer need for a speed rating of a film product is for use with an exposure meter. Photoelectric exposure meters originated in Germany about 1928 and were first made in this country about 1932. By 1937 there were half a dozen types of meters manufactured in the United States and even more imported varieties. Each manufacturer could elect to use any of several film-speed systems, and could select the indicated exposure to produce a negative of whatever density he thought desirable. Reputable exposure meters intentionally differed by as much as one *f*-stop.

The end of this confusion started in 1938 with the organization of Committee Z38 of the American Standards Association under the leadership of L. A. Jones and Paul Arnold. This committee brought together manufacturers, consumers, and other interested groups for the purpose of standardization. The exigencies of World War II forced agreement on methods of measuring and expressing many photographic parameters, including camera exposure. Since then, the war emergency standards have been revised, improved, and expanded to include interchangeability, dimensions, units, nomenclature, testing procedures, and quality relating to all types of photographic materials and apparatus. Photographic measurements have been rationalized almost completely by American Standards. International standardization is progressing. These voluntary standards simplify photography for all.

New Nomenclature

In the latest revision of PH2.12, American Standard for General Purpose Exposure Meters,¹ new symbols and nomenclature appear. The high speeds of new films, for example ASA 1250, require four-digit numbers on exposure meters. The miniature meters of today cannot accommodate a scale of four-digit numbers without a sacrifice of legibility. Accordingly, the exposure meter subcommittee proposed a new scale of film-speed numbers composed of single digits. The new series—0, 1, 2, 3, 4, 5, 6, 7, 8, and 9—is a logarithmic series, base 2, and designates the same film sensitivities as the alternate familiar arithmetic series—3, 6, 12, 25, 50, 100, 200, 400, 800, and 1600—which it is expected to replace. The log series are called film-speed values to distinguish them from the arithmetic film speeds. The two should not be confused, as the series of numbers do not overlap for any commonly used films.

The camera exposure formulas^{1,2} (see Table I for nomenclature)

$$SxB/K = 2^{Ev} = A^2/T \quad (1)$$

can be written

$$\log_2 Sx + \log_2 B - \log_2 K = Ev = \log_2 A^2 + \log_2 (1/T) \quad (2)$$

The left side of this equation can be rearranged without changing the equality,

$$\log_2 Sx + \log_2 (B/K) = Ev, \quad (3)$$

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* Members of the ASA Subcommittee PH2/11, Photographic Exposure Meters, who have been concerned with the revision discussed in this paper are: Messrs. A. Boch, T. Briskin, G. Dougan, R. French, M. LaRue, Jr., C. McCamy, D. Merrill, H. Morse, C. Nelson, P. O'Neill, J. Schimoler, A. Stimson (Chairman), M. Townsley, V. Whitman, and A. Williams.

1. American Standard for General Purpose Photographic Exposure Meters, PH2.12-1961.
2. Allen Stimson, *Phot. Sci. Eng.*, 4: 203 (1960).

TABLE I. Nomenclature for Exposure Parameters

Arithmetic system ^a	Additive (APEX) system	Relationship
Ev = Exposure value $2^{Ev} = \frac{A^2}{T}$ $= \frac{BSx}{K} = \frac{B_0Sx}{K_0}$ $= \frac{ISx}{C}$	Ev = Exposure Value $Ev = Av + Tv$ $= Bv + Sv$ $= Iv + Sv$	
T = Effective shutter time, sec	Tv = Time value	$2^{Tv} = \frac{1}{T}$ $Tv = 3.32 \log_{10} \frac{1}{T}$
A = Actual f -number of lens diaphragm	Av = Aperture value	$2^{Av} = A^2$ $Av = 3.32 \log_{10} A^2$
Sx = ASA speed (of film) ^c	Sv = ASA speed value	$2^{Sv} = NSx$ $Sv = 3.32 \log_{10} NSx$
B = Field luminance, ft-L ^d	Bv = Luminance value ^b	$2^{Bv} = \frac{B}{KN}$ $Bv = 3.32 \log_{10} \frac{B}{KN}$
B_0 = Field luminance, c/sq ft ^d		$= \frac{B_0}{K_0N}$ $Bv = 3.32 \log_{10} \frac{B_0}{K_0N}$
K = Exposure constant (reflected light)		
K_0 = Exposure constant (reflected light)		
C = Exposure constant (incident light)		
I = Incident light (ft-c) ^e	Iv = Incident-light value	$2^{Iv} = \frac{1}{CN}$ $Iv = 3.32 \log_{10} \frac{1}{CN}$

^a $B = \pi B_0$; $K = \pi K_0 = 3.33 \pm 0.50$; $K_0 = 1.06 \pm 0.16$; $C = 20.8 \pm 5$; $N^b = 0.30$.

^b The value of N is established in PH2.5-1960.⁴ It is a constant which was chosen to establish the relation between Sx and Sv , shown in Table II.

^c The abbreviated designation of American Standard Speed, Sx , for example, may be written ASA 25, and that for Sv may be written ASA 3°.

^d The footlambert (ft-L) is the preferred unit to avoid confusion between candles per square foot (c/sq ft) and footcandles (ft-c).

^e Illuminance. The footcandle (ft-c) is the preferred unit.

and the independent parameter N can be introduced as

$$\log_2 NSx + \log_2 (B/NK) = Ev. \quad (4)$$

If symbols are substituted,

$$Sv = \log_2 NSx \quad (5)$$

$$Bv = \log_2 (B/NK) \quad (6)$$

$$Av = \log_2 A^2 \quad (7)$$

$$Tv = \log_2 (1/T), \quad (8)$$

Eq. (2) may be written as

$$Sv + Bv = Ev = Av + Tv \quad (9)$$

It is obvious the Bv is not an absolute photometric unit of luminance since it involves the parameters N and K . The K was included in Bv for simplicity of Eq. (9). The value $N = 0.30$ was selected in cooperation with Subcommittee PH2/18 to make film speed 3 correspond approximately with film-speed value 0°. (The degree notation (°) was used in the previous standard³ to distinguish the logarithmic exposure indexes and is now retained⁴ to distinguish speed values.)

Fortunately, it was possible to select a value $K = 3.333$ which would make the luminance value $Bv = 0$ correspond exactly to field luminance of 1 ft-L. Thus, the scale of luminance values given in

Table II is exact only when the meter is calibrated for the exposure constant $K = 3.333$. The standard permits the manufacturer to select a value for K within the limits $K = 3.333 \pm 0.50$.

The new value $K = 3.333$ is used when the meters are calibrated at 4700°K. The former value $K = 3.6$, which has been used when the meters⁵ were calibrated at 2700°K, is 10% greater because the average cell is about 10% less sensitive at this color temperature. Consequently, no radical change in calibration of reputable American-made meters is anticipated. However, all meters which conform will be more uniform. It is expected that different manufacturers will in the future agree more closely on the value of K , so that the tolerance on $K = 3.333$ of ± 0.50 can be reduced.

The footlambert (ft-L) is now the preferred unit of luminance (brightness) to avoid confusion between the unit, candle per square foot, and the unit of illuminance, the footcandle (ft-c).

The incident-light value Iv involves the constant C which can vary $\pm 24\%$ within the limits of the standard and at the option of the meter designer. Incident light, as defined in the Standard for Photographic Exposure,¹ is measured at the subject position in a plane normal to the direction of the camera. However, illumination for visual purposes is ordinarily measured in a horizontal plane. For these reasons, photographic incident-light data may

3. American Standard Method for Determining Photographic Speed and Exposure Index, PH2.5-1954. American Standards Association, 10 E. 40 St., New York 16, N. Y.

4. American Standard Method for Determining Speed of Photographic Negative Materials, PH2.5-1960.

5. American Standard for General Purpose Photographic Exposure Meters, PH2.12-1957.