

ANSI PH3.49-1971

# American National Standard

*for General-Purpose  
Photographic Exposure Meters  
(Photoelectric Type)*



**American National Standards Institute**

11 West 42nd Street  
New York, New York  
10036

**ANSI**  
**PH3.49-1971**  
Revision and  
Redesignation of  
PH2.12-1961

**American National Standard  
for General-Purpose  
Photographic Exposure Meters  
(Photoelectric Type)**

Secretariat

**National Association of Photographic Manufacturers, Inc**

Approved April 27, 1971

**American National Standards Institute, Inc**

## Foreword

(This Foreword is not a part of American National Standard for General-Purpose Photographic Exposure Meters (Photoelectric Type), PH3.49-1971.)

This standard is the result of the cooperative effort of manufacturers of photographic film and exposure meters, as well as users. It is a revision and redesignation of American National Standard PH2.12-1961 and includes significant changes and simplifications which benefit the industry and the consumer.

American National Standard PH3.49-1971 is one of a series of American National Standards covering many aspects of photography. At the present time, there are eight American National Standards Committees working on the various standardization problems in the field of photography. They are responsible not only for the development of new standards, but for revisions of old standards as well. These committees are constantly on the alert for new developments in the art of photography and periodically review all approved photographic standards with a view to reaffirmation, revision, or withdrawal.

The project on photography was initiated under the procedures of the Standards Institute in 1938. The committee which was organized to carry on this work was designated as the Standards Committee on Standardization in the Field of Photography, Z38. This committee continued in operation for over ten years, under the sponsorship of the Optical Society of America, and was responsible for the development of well over one hundred American National Standards in the photographic field.

In 1950, it became apparent that it was not feasible for one committee to handle such a large assignment, and on November 30, 1950, Standards Committee Z38 was disbanded and four new committees were organized to replace it. Four additional committees have since been organized.

The American National Standards Committee on Photographic Apparatus, PH3, which revised this standard, is one of the eight photographic committees. The secretariat of PH3 is held by the National Association of Photographic Manufacturers, Inc. The PH3 Committee has the following scope:

Standards for apparatus and procedures used for exposing, printing, and viewing photographs.

In addition to participating in the national standardization program, the PH3 Committee is also concerned with the work being carried on by the National Association of Photographic Manufacturers, Inc, acting for the secretariat of Technical Committee 42 on Photography, of the International Organization for Standardization (ISO). The American National Standards Institute, representing the United States, holds the secretariat for ISO/TC 42. The ISO is a federation of the national standardizing bodies in the principal industrial countries of the world. It is the successor organization to the International Federation of National Standardizing Associations (ISA). Through the American National Standards Institute, this and other American National Standards may be placed before the member nations of ISO for consideration and possible international adoption.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

At the time it approved this standard, the American National Standards Committee on Photographic Apparatus, PH3, had the following members:

Robert J. Hudak, Chairman  
David C. Harper, Vice-Chairman  
A. Thomas Hallowell, Secretary

<i>Organization Represented</i>	<i>Name of Representative</i>
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U.S. Department of the Navy .....	Charles M. Bailey
	William Pera (Alt)
Xerox Corporation .....	David C. Harper
	John D. Hayes (Alt)

Subcommittee PH3-3 on Standards for Photoelectric Exposure Meters, which was responsible for the development of this standard, had the following personnel:

Allen G. Stimson, Chairman

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# American National Standard for General-Purpose Photographic Exposure Meters (Photoelectric Type)

## 1. Scope and Purpose

**1.1 Scope.** This standard applies to general-purpose photoelectric exposure meters which measure reflected light or incident light, or both, in determining photographic exposure for camera use. It applies to meters containing a light-sensitive element; an indicating electrical instrument calibrated in suitable units, such as the units of luminance, illuminance, or some factor of photographic exposure; a directional system when used; and a computer to correlate the meter indications with the camera exposure settings for the particular photographic film being used.

**1.2 Purpose.** This standard is intended to serve as a guide to the manufacturer of exposure meters in designing and testing his product. It defines the terms used in describing the performance of exposure meters and establishes limits where practicable. It establishes a basis for uniform markings and nomenclature consistent with other American National Standards.

## 2. General Design and Construction

The general design and construction of photographic exposure meters shall be mechanically sound, suitable for the intended use and purpose, and shall ensure permanency in the accuracy of indications.

## 3. Detailed Requirements

**3.1 Legibility.** The requirements given in 3.1 are designed to minimize errors resulting from reading the instrument indication incorrectly.

**3.1.1 Instrument-Scale Cover.** The instrument scale shall be provided with a transparent cover of glass or other material having adequate thickness, durability, and practical freedom from electrostatic effect and such imperfections (scratches, striae, etc) as would impair scale legibility at twenty inches from the eye.

**3.1.2 Instrument Scale.** The instrument scale and its transparent cover shall be so designed that any scale

division line is visible to an observer of normal acuity from any angle up to 20 degrees from a line perpendicular to the scale.

**3.1.3 Scale Markings.** The instrument and computer scale markings shall not be closer than 0.015 inch (0.038 cm) from center to center and shall be as large and legible as practicable. Numbers should be spaced so that individual digits are clearly distinguishable from adjacent ones. The deflection of the pointer tip shall be at least 0.025 inch (0.063 cm) for each factor-of-2 change in light beyond the first marked division line.

**3.1.4 Pointer.** The instrument pointer shall be suitably formed to permit accurate reading at the usual viewing distance and shall be distinguishable up to the limit of legibility of the scale markings. Parallax shall be minimized by suitable location of the pointer.

**3.2 Zero Adjuster.** If the instrument incorporates a zero-adjusting device, the device should have sufficient inherent friction to maintain a stable adjustment when the instrument is subjected to the shocks and vibrations of normal use.

With no illumination on the cell, any external zero adjuster shall provide for an adjustment range, above and below the scale point, of at least 2 percent of the scale length.

**3.3 Balance.** The moving-coil system of the instrument shall be statically balanced to permit accurate indication in any position. The balance shall be adequate to pass the following test:

With no illumination on the cell and with the axis of the moving system substantially vertical, the instrument pointer of the meter shall be set at zero. With the axis of the moving system horizontal, the instrument shall be rotated to the left, around the moving-system axis, through an angle of 90 degrees from the position in which the pointer is horizontal to the position in which it is vertical. The position of the pointer tip shall not deviate from zero by more than 2 percent of the calibrated scale length when the instrument is vibrated slightly by tapping it with the finger.

## 3.4 Exposure Computer and Meter Markings

**3.4.1 Nomenclature.** The exposure-parameter mark-

ings shown on the computer or scale of the instrument shall be compatible with the preferred symbols, abbreviations, and relations itemized in Table 1. Formulas and constants are also given in this Table.

**3.4.2 Relative-Aperture Scale.** Numbered aperture markings shall be selected from the series of relative apertures given in Table 2. The symbol for relative apertures shall be  $f/$  followed by the  $f$ -number.

Intermediate scale divisions may be used and may be numbered.

**3.4.3 Exposure-Time Scale.** Shutter-speed markings shall be selected from the series of effective time intervals tabulated in Table 2. Symbols shall be in accord-

**Table 1**  
**Formulas and Nomenclature for Exposure Parameters**

$$2E_v = \frac{A^2}{T}$$

$$= \frac{BS}{K} = \frac{IS}{C}$$

$$K = \frac{K_0 r}{t}$$

where

$K_0$  = value of  $K$  when  $r = 1$ ,  $t = 1$

$E_v$  = exposure value\*

$T$  = effective exposure time, in seconds

$A$  = actual  $f$ -number of lens diaphragm

$S$  = American National Standard Speed (of film)†

$B$  = field luminance, in footlamberts

$K$  = exposure constant (reflected light)

$C$  = exposure constant (incident light)  
=  $30 \pm 5$

$I$  = incident light, in footcandles (illuminance)

$r$  = spectral response ratio of cell

$t$  = lens transmittance

Nominal Values of Exposure Constants (For Calibration at 4700 K)‡				
	8mm Films		Larger Films	
	Metric	English	Metric	English
$K_0 \S$ =	14.2**	4.15	11.4**	3.33
$r \S$ =	1.0††	—	1.0††	—
$t \S$ =	0.9	—	0.9	—
$K \S$ =	15.6**	4.55	12.5**	3.64

\*See Appendix A.

†See 3.4.4.

‡See Appendix C.

§See 4.1.1 and Appendixes C and D.

\*\*Nit (candelas/square meter).

††For daylight.

**Table 2**  
**Preferred Exposure Parameter Numerals**

Time $T$	Aperture $A$	Film Speed* $S$
1	1	3
1/2	1.4	6
1/4	2	12
†-- 1/8	2.8	25
1/15	4	50
1/30	5.6	100
1/60	8	200
1/125	11	400
1/250	16	800
1/500	22	1600
1/1000	32	3200

\*For complete table of speeds, see American National Standard Method for Determining Speed of Photographic Negative Materials (Monochrome, Continuous-Tone), PH2.5-1960.

†The tabular values of  $T$ ,  $A$ , and  $S$  are rounded off to a uniform series of numbers which are easy to remember. However, the actual numbers to be used in designing and calibrating equipment are in a power-of-2 geometric progression starting with the precise values of the figures on the fourth line. The precise value of  $f/2.8$  is  $\sqrt{8}$ .

ance with the nomenclature in Table 1. If intermediate divisions are used, they may be numbered.

**3.4.4 Film Speed Markings.** Film speed<sup>1</sup> markings shall be selected from the series given in Table 2. Intermediate markings shall be in cube-root-of-2 steps.

For convenience, American National Standard Speed,  $S$ , may be identified by an abbreviated designation of the general form "ASA 25."

**3.4.5 Inherent Computer Error.** The error in exposure indication caused by the computer shall not exceed  $\pm 0.167 E_v$ . This error can be determined as described in 4.1.3.

**3.5 Temperature Influence.** The maximum permanent change in indication at 25°C (77°F) due to exposure of the meter to the extreme temperatures — 35°C (— 31°F) and 70°C (158°F) shall not exceed  $\pm 0.33 E_v$ . The change in instrument indication due to a change of  $\pm 20^\circ\text{C}$  (36°F) from the reference temperature 25°C (77°F) shall not exceed  $\pm 0.33 E_v$ .

The exposure meter shall be placed in air maintained at constant temperature within  $\pm 3^\circ\text{C}$  (5.4°F) at each prescribed temperature for a minimum time of one hour before any readings are taken. Readings shall be taken at approximately one-half angular scale deflection with a tungsten light source having effective color temperature between 2680 K (kelvin) and 2854 K.

<sup>1</sup>See American National Standard Method for Determining Speed of Photographic Negative Materials, (Monochrome, Continuous-Tone), PH2.5-1960.



**3.6 Color-Temperature Conversion Filters and Diffusing Sandwich for Calibrating Exposure Meters.** The working standard for meter calibration shall consist of a 2854 K tungsten source in combination with filters specified in this section. The size and thickness are not mandatory so long as other characteristics are within the limits given in 3.6.3 and 4.1.3.5. This filter closely matches the Davis and Gibson filter described in Appendix B.

The components are a blue glass filter and a sandwich (comprising another blue glass and a diffusing filter). The purpose of this section is to provide means for easily and accurately reproducing illuminance and luminance at 4700 K to obtain close agreement in calibration between meters made by different companies and tested by different laboratories, without sacrifice of calibration tolerances.

**3.6.1 Application of Glass Color-Temperature Conversion Filter.** The blue filters are used in the light beam from the standard lamp, as on the photometric bar, in calibrating incident-light meters. The receiver of the incident-light meter is placed near the blue glass.<sup>2</sup>

<sup>2</sup>When the receiver is placed against the filter, interreflections between receiver and filter may introduce an error. The possible discrepancy can be minimized by placing the receiver four or five inches from the surface. However, the diffusing filter must then be much larger to subtend the same angular field.

**3.6.2 Application of Diffusing Sandwich.** The diffusing sandwich is intended for use on the photometric bar as a 4700 K, uniform diffusing-surface source, the luminance of which can be easily varied by changing the lamp distance. The receiver of the meter is placed against the emitting surface of the diffusing filter with the blue glass side facing the lamp.<sup>2</sup>

**3.6.3 Physical Specifications.** See Table 3.

**3.6.3.1** The blue glass may be of greater thickness for Item 2 than for Item 1. The required color temperature conversion of the blue glass in the sandwich is greater because the diffusing filter tends to reduce the color temperature. There should be no irregularities in the spectral transmittance of the blue glass which would cause the emitted radiation to differ markedly in effect from that of a blackbody at 4700 K throughout the visible portion of the spectrum.

**3.6.3.2** The blue glass shall be nondiffusing so that its use will not impair the accuracy of computing illuminance by the inverse square law.

The illuminance at 4700 K will be that computed for 2854 K multiplied by the luminous transmittance ( $F$ ) of the glass. (See 3.6.5.1.)

**3.6.3.3** The luminous directional transmittance ( $D$ ) is the luminance of the emitting diffusing filter surface per unit of illuminance on the incident blue glass surface when transilluminated in the normal direction by an axial point source. It may be expressed in

Table 3  
Physical Specifications

	Blue Filter	Diffusing Sandwich
	for Calibrating Incident-Light Meters	for Calibrating Reflected-Light Meters
Item number	1	2
Size		
Dimension of square, millimeters	165.0 (6.500 in.)	165.0 (6.500 in.)
Tolerance, millimeters	$\pm 1.6 (\pm 0.062 \text{ in.})$	$\pm 1.6 (\pm 0.062 \text{ in.})$
Thickness (minimum), millimeters	3.18 (0.125 in.)	9.50 (0.375 in.)
Number of filters in each assembly	1	2
Color conversion		
Color temperature of incident radiation, kelvin (CIE Illuminant A)	2854	2854
Color temperature of emitted radiation $\pm 200$ K	4700	4700
Corning blue daylight glass (see 3.6.3.1)	No. 5900	No. 5900
Luminous transmittance (see 3.6.3.2)	0.24*	—
Diffusing sandwich		
Luminous directional transmittance (see 3.6.3.3 through 3.6.3.5)	—	0.11*

\*Representative values. See 3.6.5.

units of nits per lux<sup>3</sup> or footlamberts per footcandle. (See 3.6.5.2.)

**3.6.3.4** The uniformity of transmission of the sandwich shall be such that its minimum luminance when illuminated in the normal direction by an axial point source located at a distance 15 times the maximum dimension of the sandwich, will not be less at any point than 90 percent of its maximum luminance measured in the normal direction at any other point.

**3.6.3.5** The diffusion characteristics of the sandwich shall be such that the luminance of any point measured from any angle not exceeding 60 degrees from the normal shall be not less than 85 percent of the luminance of the same point measured from the normal direction. The sandwich shall be illuminated as described in 3.6.3.4.

**3.6.4 Uniformity of Filters.** The original lot of blue filters and diffusing sandwiches produced in accordance with this standard were made from single lots of material to ensure maximum uniformity.

The limits for luminous transmittance and luminous directional transmittance were determined from tests of actual parts by the National Bureau of Standards.

**3.6.5 Certification and Calibration of Glass Filters and Diffusing Sandwiches.** The filters and diffusing sandwiches are described in *Standard Filters for Calibrating Photographic Exposure Meters*, National Bureau of Standards Report No. 7704, September 1962. They may be obtained with certified calibration from the National Bureau of Standards in the units defined in 3.6.5.1 and 3.6.5.2.

**3.6.5.1 Calibration of Blue Glass.** The units for calibration of blue glass are as follows:

$F$  = luminous transmittance  
 =  $\frac{\text{transmitted illuminance in footcandles at 4700 K}}{\text{incident illuminance in footcandles at 2854 K (tungsten)}}$

**3.6.5.2 Calibration of Diffusing Sandwich.** The units for calibration of diffusing sandwich are as follows:

$D$  = luminous directional transmittance  
 =  $\frac{\text{emitted luminance in footlamberts at 4700 K}}{\text{incident illuminance in footcandles at 2854 K (tungsten)}}$

**3.7 Spectral Sensitivity.** The spectral sensitivity of the exposure meter shall be continuous in the range between 350 nm (nanometers) and 700 nm. For the same response of the light detector the luminance (or illuminance) at 2854 K shall be within  $\pm 0.25 E_v$  of that at 4700 K.

<sup>3</sup>Lux is the metric unit of illuminance expressed in lumens per square meter.

A tungsten lamp operated at 2854 K and the 4700 K source described in 3.6 shall be used.

### 3.8 Other Requirements

**3.8.1 Test Voltage.** The batteries if used may be replaced with a regulated dc power supply operating at the following voltages:

Zinc carbon batteries	1.40 volts
Manganese alkaline batteries	1.40 volts
Mercury batteries	Nominal voltage
Silver oxide batteries	Nominal voltage

**3.8.2 Light-Adaptation History Effect.** Both photovoltaic and photoconductive cells manifest time-dependent changes in response at constant illumination. A change in illumination causes "fatigue" of selenium cells. The response of a photoconductor is dependent on its past history of exposure to light and temperature. While these changes are ordinarily less than  $\pm 0.5 E_v$ , they must be recognized if reproducible test results are to be obtained. However, the initial accuracy shall be within the limits of this standard under conditions of normal use.

Exposure meters tested in accordance with this standard may be preconditioned as prescribed for normal use in the instruction book furnished by the manufacturer.

Daylight for the purpose of this test is within a factor-of-2 of 3426 nits, or 1000 fL, or a corresponding illuminance on the cell. The color temperature should exceed 2854 K.

**3.8.2.1 Drift Error.** When the dark-adapted meter is suddenly exposed to daylight, the readings after five seconds and after one hour shall not differ more than  $\pm 0.25 E_v$ .

**3.8.2.2 Recovery Error.** When the daylight-adapted meter is suddenly exposed to light four times its minimum indication, the readings after five seconds and after one hour shall not differ by more than  $\pm 0.25 E_v$ . The testing luminance shall not be lower than 3.1416 nits.

**3.8.3 Life Test of Batteries.** The life of batteries if used shall be measured by continuously exposing the device to daylight as defined in 3.8.2 until the indicated exposure has changed approximately  $0.25 E_v$  at 25°C.

## 4. Requirements for Reflected-Light Exposure Meters

### 4.1 Calibration

**4.1.1 Calibration Formulas.** The instrument-computer combination shall be calibrated in accordance with the formulas in Table 1.

The exposure constants  $K$  and  $C$  may be assigned values in accordance with Table 1 unless the design parameters differ from the assumptions explained in Appendix C. In this case, new values may be computed as outlined. The value of  $K$  or  $C$ , or both, shall be marked on the nameplate of the exposure meter or given in the instruction manual furnished with the meter by the manufacturer. The manufacturer may choose the value which results in optimum exposure for the most critical film, usually color film.

**4.1.2 Calibration Accuracy.** In determining the photometric accuracy of the instrument, the actual luminance required to produce a given scale deflection is compared with the average luminance value determined from the computer's film, lens, and shutter data corresponding with the selected scale point. Indications over the angular center half of the scale shall be within  $\pm 0.333 E_v$  and within  $\pm 0.5 E_v$  for all other usable points on the scale. If two scales are used, the multiplying means shall not introduce an additional error exceeding  $\pm 0.167 E_v$ .

**4.1.3 Calibration Test.** The calibration accuracy of the instrument shall be measured by exposure to a surface source of known luminance. The equipment and test conditions shall be as given in 4.1.3.1 through 4.1.3.9.

**4.1.3.1 Ambient Temperature.** The ambient temperature shall be  $25^\circ\text{C} \pm 5^\circ\text{C}$  ( $77^\circ\text{F} \pm 9^\circ\text{F}$ ).

**4.1.3.2 Test Position.** The calibration test position shall be the same as that of normal use.

**4.1.3.3 Zero Adjustment.** The zero adjustment shall be carefully made prior to checking calibration. This shall be done with no illumination on the cell.

**4.1.3.4 Bearing Friction.** The meter or its support should be vibrated at the moment of reading the instrument, to eliminate friction errors. This may be done by lightly tapping the device, as with the finger.

**4.1.3.5 Light Source.** The surface source used for calibration shall have a color temperature of 4700 K  $\pm 200$  K produced in accordance with the specifications outlined in 3.6. The area of the surface source subtended by the field of the meter shall be large enough so that the indicated luminance does not change more than  $\pm 5$  percent when the meter is rotated about its point of contact with the source by five degrees in any direction.

**4.1.3.5.1 Diffusion Method.** The surface source shall be the emitting surface of the diffusing sandwich, specified as Item 2 in Table 3, when trans-illuminated by a standard tungsten lamp. This apparatus may be conveniently mounted on a rigid structure equivalent to a photometric bar on which the distance from sandwich to lamp can be varied and measured

accurately. The blue glass side of the sandwich must face the lamp.

Baffles should be placed between lamp and sandwich to exclude all but direct light. For most accurate readings, the distance between lamp and sandwich should be at least ten times the illuminated diameter of the sandwich.

The luminance of the emitting surface of the sandwich is computed by the formula:

$$B = D \frac{hcp}{d^2} \quad (\text{Eq 1})$$

where

$B$  = luminance in nits or footlamberts

$D$  = luminous directional transmittance of sandwich (see 3.6.5.2)

$hcp$  = horizontal candlepower of the standard lamp in the marked direction

$d$  = distance in meters or feet from lamp filament to nearer surface of the diffusing filter in the sandwich

The lamp should be operated on the voltage or current (within  $\pm 0.25$  percent) at which it was standardized for candlepower and color temperature.

The luminance of the source can be varied by changing the lamp distance or the candlepower of the lamp.

The light receiver of the meter to be calibrated is placed in contact with the center of the emitting surface of the diffusing filter of the sandwich. See 3.6.2.

**4.1.3.6 Test Procedure.** To determine computer and instrument errors, proceed as follows:

(1) Select instrument-scale points ( $C$ ,  $D$ ,  $E$ , and  $F$ ) at approximately the center of each of the four angular quarters of the scale length. Using these marked values, set the calculator dials to four widely different values of aperture and exposure time. If the resultant value of film speed is not a marked value, estimate its value as closely as possible, remembering that divisions are usually in cube-root-of-2 steps, and that logarithmic interpolation is needed.

(2) By means of the formulas in Table 1, determine the theoretical values  $B_1$  for each of the combinations chosen above. Use the precise values of the exposure parameters (that is,  $f/\sqrt{8}$  for  $f/2.8$ ) and the manufacturer's value for  $K$ . The example in Table 4 is based on  $K = 3.2$  and the use of the formula:

$$B = \frac{KA^2}{TS} \quad (\text{Eq 2})$$

derived from Table 1.

(3) Select  $B'_1$ , the value of  $B$  which deviates most from the value  $B_2$ .

(4) The maximum deviation ( $B_2 - B'_1$ ) of any one value of  $B_1$  from its group average  $B_2$  in any angular quarter of the scale is the measure of the computer accuracy.

(5) Determine by photometric tests the actual luminance  $B_3$  required for each of the four scale values selected. (For method of measuring luminance, see 4.1.3.7.) Vibrate instrument to minimize friction error.

(6) The difference between the measured value  $B_3$  and the average value  $B_2$  is the measure of the calibration (photometric) accuracy at that point.

(7) The formulas for the percent deviation are shown in the example illustrated in Table 4.

(8) The fractional Exposure Value equivalents expressed in terms of percent error are:

$E_v$ Units	Percent Error	
	Maximum	Minimum
$\pm 1/6 E_v$	+ 12 percent	- 11 percent
$\pm 1/4 E_v$	+ 19 percent	- 16 percent
$\pm 1/3 E_v$	+ 26 percent	- 21 percent
$\pm 1/2 E_v$	+ 41 percent	- 29 percent

**4.1.3.7 Photoelectric Method for Measuring Luminance.** The luminance of an extended source may be determined by dividing its apparent candlepower by its area. The apparent candlepower may be determined on the basis of the inverse square law, and is the product of the illuminance in footcandles

produced at any plane multiplied by the square of the distance of the plane from the source. The inverse square law is applicable if the distance at which the illuminance is measured is over ten times the diameter of the source or aperture of the meter, whichever is larger.

In measuring the source luminance, the source can be masked with opaque material having an arbitrary aperture of convenient area, as 0.01 square foot. All light except that from the aperture must be excluded. The illuminance due to the aperture can be measured at any axial point; for example, 1.4 feet from the mask. This can be done with a photoelectric light meter which might read 1 footcandle at 1.4 feet. The apparent candlepower of the source would then be:  $1 \times 1.4 \times 1.4 = 1.96$  candlepower. The luminance of the source would be:  $1.96/0.01 = 196$  candelas per square foot or  $196 \pi = 616$  footlamberts.

The photoelectric light meter should be calibrated at the measured points immediately after the test by the method described in 5.3.6.

In measuring luminance from any angle, the illuminance is first measured in the desired direction. The area of the aperture (for a thin mask) used in computing the luminance is the actual area multiplied by the cosine of the angle from the normal.

**4.1.3.8 Reference Exposure.** For comparison of meter calibrations, the reference exposure shall be  $1/60$

Table 4  
Example of Exposure-Meter Calibration Check

Scale Value	Assume		Compute On Dials	Use for Calculating $B_1$			Values of $B$			Percent Deviation	
							(Assume $K = 3.2$ ) $\frac{KA^2}{TS}$	Group Average of $B_1$	Measured Photometric Value $B_3$	Computer $100 \frac{(B_2 - B'_1)}{B_2}$	Photometric $100 \frac{(B_3 - B_2)}{B_2}$
	$A$	$T$	$S$	$A$	$T$	$S$					
C	2.0	1/15	6.2	2	1/16	6.2	33.1				
	5.6	1/30	100	$\sqrt{32}$	1/32	100	32.8				
	16	1/60	1650	16	1/64	1650	31.8				
	32	1/4	420	32	1/4	420	31.3	32.2	33.1	34	- 3
D	2.0	1/125	17	2	1/128	17	96				
	5.6	1/60	65	$\sqrt{32}$	1/64	65	101				
	16	1/30	26	16	1/32	260	101				
	32	1/8	250	32	1/8	250	105	101	96	99	+ 5
E	2.0	1/250	11	2	1/250	10.7	298				
	5.6	1/500	150	$\sqrt{32}$	1/512	150	349				
	16	1/60	160	16	1/64	160	327				
	32	1/4	41	32	1/4	41	320	324	298	301	+ 8
F	2.0	1/1000	12.3	2	1/1024	12.3	1070				
	5.6	1/250	26	$\sqrt{32}$	1/256	26	1010				
	16	1/30	25	16	1/32	25	1050				
	32	1/60	51	32	1/16	50	1050	1040	1010	900	+ 3

second, at  $f/4$ , for film speed  $S$  of 25. The calibrations shall be compared in terms of the scene luminance required for this exposure.

**4.1.3.9 Production Testing.** When the test methods prescribed in this standard are not convenient for production testing, methods giving equivalent results may be used.

**4.2 Acceptance.** The directional characteristics of an exposure meter may be measured in terms of its cell acceptance, and specific and oblique acceptance angles.

**4.2.1 Cell Acceptance.** The cell acceptance ( $Ca$ ) of an exposure meter is the ratio of the actual luminance, measured by the complete meter, to the actual illuminance, normal to the bare cell, which will result in the same scale indication. The tests may be made with tungsten sources at  $2854\text{ K} \pm 150\text{ K}$  if more convenient than  $4700\text{ K}$ . The preferred units are footlamberts per footcandle.

The cell acceptance relates the characteristics of a bare cell and instrument to their performance when assembled into an exposure meter. It is useful to a designer who may purchase cells and instruments from one source, and the directional means from another. Cell acceptance is one measure of the attenuation of the directional means.

The luminance source shall have the uniformity and goniometric characteristics described in 4.1.3.5.

The point source shall be equivalent to that described in 5.3.5 except for color temperature.

The test proceeds as follows: The exposure meter is mounted on a conventional photometric bar with its receiver against the emitting surface of the luminance source. The luminance is adjusted so that the pointer of the meter indicates a convenient scale-division point. The bare cell is then exposed to the source of illuminance, and the illuminance is adjusted to give the same scale indication, by the method described in 5.3.6. There are no baffles, grids, lenses, or other attenuators between cell and lamp when measuring the illuminance normal to the bare cell which produces the same scale indication.

**4.2.2 Specific Acceptance Angle.** The specific acceptance angle of an exposure meter is the angle in the stated directions from the optical axis of the receiver at which the point source must be placed to reduce the scale reading of the meter an amount corresponding to 50 percent of the original light reading when the same point source was on the optical axis. Specific acceptance angles shall be defined by the direction of measurement with respect to the optical axis; that is, left, right, up, or down from the position of use by the photographer. The specific acceptance angle is denoted "up" when the light source is above the optical

axis of the meter, "left" when the light source is to the left of the optical axis.

The test proceeds as follows: To determine the specific acceptance angle, the meter and standard lamp may be mounted in alignment on a conventional photometric bar. The lamp position is adjusted to give a convenient low-scale reading, and its distance  $d$  from the meter aperture is noted. The lamp is then moved closer to a distance  $d/\sqrt{2}$  from the meter. The meter is then rotated about an axis through the center of its entrance aperture until the original scale indication is obtained. This angular displacement is the specific acceptance angle in the corresponding direction.

Methods or apparatus that produce equivalent results are acceptable.

**4.2.3 Oblique Acceptance Angles.** The oblique acceptance angles are the angles in the stated directions from the optical axis of the receiver at which the point source must be placed to reduce the response of the meter to an amount corresponding to 5 percent of the original light reading when the same point source was on the optical axis. It shall be measured in a manner similar to that described in 4.2.2 for specific acceptance angles.

## 5. Requirements for Incident-Light Exposure Meters

**5.1 General.** The requirements for an incident-light exposure meter are identical to those given for reflected-light exposure meters, except that calibration requires a different procedure and acceptance is not defined.

Since illuminance measurements in the photographic industry are commonly expressed in terms of footcandles, the instrument scale of incident-light-type exposure meters should preferably be calibrated in terms of lux or footcandles. However, this is not mandatory, because in some instruments it is desirable to use the same scale for other measurements in different units.

The exposure-meter-computer combination shall be calibrated in accordance with the formulas and constants given in Table 1.

**5.2 Calibration Accuracy.** In determining the overall accuracy of the meter, the deviation from the stated value of the constant  $C$  shall be considered the criterion of accuracy. Indications over the angular center half of the scale shall be within  $\pm 0.333 E_v$  of the constant  $C$  and within  $\pm 0.5 E_v$  for all other usable points on the scale. If two scales are used, the multiplying means shall not introduce error exceeding  $\pm 0.167 E_v$ .

**5.3 Calibration Test.** The calibration accuracy of the exposure meter for measuring incident light shall be measured by means of exposure to a concentrated source of known candlepower. The equipment and test conditions shall be as given in 5.3.1 through 5.3.6. Methods which produce equivalent results are acceptable.

**5.3.1 Ambient Temperature.** The ambient temperature shall be  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).

**5.3.2 Test Position.** The exposure meter shall be tested in its normal operating position.

**5.3.3 Zero Adjustment.** The instrument shall be set on zero with no illumination on the cell prior to checking calibration.

**5.3.4 Bearing Friction.** The meter or its support should be vibrated at the moment of reading the instrument, to eliminate friction errors. This may be done by lightly tapping the device, as with the finger.

**5.3.5 Light Source (Incident-Light Meters).** The light source shall be a tungsten filament, clear glass, incandescent lamp operating at 2854 K, in combination with the filter, Item 1 of Table 3, conforming to all requirements of 3.6, and providing illuminance on the meter of  $4700 \text{ K} \pm 200 \text{ K}$ .

The tungsten lamp shall be accurately calibrated for horizontal candlepower in the marked direction at the given color temperature by a recognized standardizing laboratory, such as those listed in the *Directory of Commercial Test and College Research Laboratories*, National Bureau of Standards Miscellaneous Publication No. M187, August 1947. The lamp shall be oriented with respect to the meter in the marked direction.

**5.3.6 Testing Apparatus.** During calibration, the meter and light source shall be mounted on a rigid structure equivalent to a photometric bar on which the distance from exposure meter to lamp filament can be measured accurately.

The blue glass filter should be placed in the light beam directly in front of the meter.

Black baffles or diaphragms having a matte finish should be placed between lamp and cell to exclude all but direct light rays. For accurate readings, the distance between the lamp filament and exposure meter should exceed ten times the diameter of the luminous source

or aperture of the meter, whichever is larger. The illuminance on the exposure meter shall be calculated by the following formula:

$$I = \frac{h_{cp}}{d^2} F \quad (\text{Eq 3})$$

where

- $I$  = illuminance on the exposure meter's receiver
- $h_{cp}$  = horizontal candlepower of the lamp in the marked direction at the corresponding voltage and at the color temperature stated in 5.3.5
- $d$  = distance between the exposure meter's receiver and the center of the luminous source
- $F$  = filter factor of the blue glass (see 3.6.5)

## 6. Revision of American National Standards Referred to in This Document

When the following American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, the revision shall apply:

American National Standard Method for Determining Speed of Photographic Negative Materials (Monochrome, Continuous-Tone), PH2.5-1960

American National Standard Method for Determining Speed of Reversal Color Films for Still Photography, PH2.21-1961

## 7. References to the Text

BURNS, V. I. *Standard Filters for Calibrating Photographic Exposure Meters*, NBS Report No. 7704, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C.: Government Printing Office, Sept 1962.

RAPUZZI, A. E. *Directory of Commercial Test and College Research Laboratories*, Miscellaneous Publication No. M187, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C.: Government Printing Office, Aug 1947.