90th birthday series

APEX—The Additive System of Photographic Exposure

Douglas A. Kerr

Issue 10
May 17, 2026

INTRODUCTION

The Additive System of Photographic Exposure (APEX) provides for stating in logarithmic form several factors involved in photographic exposure. In this way, calculation of the "proper photographic exposure" for a given situation may be done manually using only simple addition. Although the importance of that has largely faded since the time the system was developed, the scheme is still widely used in technical work relating to photographic exposure, especially the APEX quantity "exposure value" (E_V). This article explains the APEX system, and gives cautions about irregularities in its usage that are often encountered.

1 APEX— THE ADDITIVE SYSTEM OF PHOTOGRAPHIC EXPOSURE

The Additive System of Photographic Exposure (APEX) provides for stating several factors involved in photographic exposure in logarithmic form. In this way, calculation of the "proper exposure" for a given situation may be done manually using only simple addition.

This convenience was a principal motivation for the development of the system (first completely promulgated in 1961), which took place when the use of photographic light meters was not universal and cameras with internal exposure metering systems were almost nonexistent.

Although changes in practice and technology have diminished the importance of this objective, it is today still common and convenient to express certain exposure-related factors in APEX terms.

The factors represented in this system are:

- Exposure time (shutter speed)
- Aperture (in the f/number sense)
- Photographic exposure (the joint effect of the two above factors)
- ISO speed (film or digital imager "sensitivity")
- Metered scene luminance (brightness)
- Metered incident light illuminance (illumination)

2 BACKGROUND

2.1 "Correct exposure"

There is of course no unique way to calculate the appropriate exposure for a particular photograph based on a simple photometric measurement, especially if we consider the diverse artistic and technical objectives that may be involved and the range of properties that the scene might exhibit.

By "correct exposure" in this article I mean the exposure that would be arbitrarily dictated by a widely-accepted mathematical relationship, the exposure we would expect to have "recommended" by a properly-performing photographic exposure meter.

2.2 Base 2 logarithms

The APEX definitions of exposure factors utilize "base 2" logarithms. As a result, a difference of one unit in an APEX value corresponds to a 2:1 difference in the actual factor, a difference that photographers call "one stop".[1] Thus, experienced photographers can readily appreciate the significance of changes in factors expressed in APEX terms.

The base 2 logarithm of a number can be calculated by taking the common (base 10) logarithm ("log") of the number and dividing that by the common logarithm of 2 (which is approximately 0.3010).

2.3 Terminology and notation

The various exposure factors in their APEX forms are all spoken of as "values", as for example "aperture value". The word "value" is thus an arbitrary cue that the APEX (logarithmic) form of the factor is meant.

But I will at time also unavoidably use the word "value" in its usual sense. Hopefully the context will be such that this causes no ambiguity.

Formally, the symbols for the APEX values all have a "v" subscript, as A_v (subscript lower-case "V"). In documents where subscripts cannot be rendered, the symbols are presented this way: Av (lower-case "V"). And in fact, I will use this convention here, since it is what is most often seen.

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[1] The term most directly relates to *aperture*. It goes back to the time when cameras were first equipped for control of aperture. Commonly, a metal plate carrying a number of holes of different diameter passed through a transverse slot in the lens barrel. It was said to "stop down" the lens aperture, and the different holes were said to be "stops". The photographer moved the plate to put into place the appropriate stop for a particular exposure. Commonly, successive holes had areas that differed by 2:1. Thus a 2:1 change in aperture area came to be known as a "one stop" change.

It is customary for the tables showing the APEX forms of the various factors to cover the range of integer values from 0 through 10 or so. Values outside that range may of course occur. Negative and fractional values are also perfectly meaningful.

I will be speaking of two distinct factors having the unfortunately-similar formal names *luminance* and *illuminance*. To avoid confusion between these terms, I will often state, parenthetically, the less precise but more readily distinguishable terms *brightness* and *illumination*, respectively. ("Brightness" is the term used in APEX anyway.)

3 ORIGIN AND STATUS

American Standard ASA PH2.5-1960, American Standard Method for Determining Speed of Photographic Negative Materials (Monochrome, Continuous-Tone) prescribed two ways of stating the sensitivity of the film (called, for historical reasons, the speed" of the film), one "arithmetic[2]" (often called at the time the "ASA speed" (written, for example, "ASA 100"), and the other "logarithmic" (written, for example, for the same speed, "ASA 5°"[3]). The latter form became the APEX speed value, S_V.

If we double the arithmetic film speed rating, the logarithmic film speed rating increases by one unit. Thus a film with speed ASA 200 can also have its speed described as ASA 6°; a film with speed ASA 50 can also have its speed described as ASA 4°.[4]

The narrative that introduced the latter form went on to observe that it would probably be desirable to establish optional logarithmic representations of all the factors involved in exposure metering, which it recommended be called the "Additive System of Photographic Exposure (abbreviated "APEX"). An example set of defining equations was given, essentially those that became the basis of the APEX system. Thus that standard actually created APEX, even though it was considered formally that it didn't.

The APEX system of notation itself was first promulgated by American Standard ASA PH2.12-1961, *American Standard General-Purpose Photographic Exposure Meters (Photoelectric Type)*. But it was essentially dead on arrival, being rendered irrelevant by the then-current tools and techniques of exposure metering.

That standard was superseded by American National Standard ANSI PH3.49-1971, *American National Standard for general-purpose photographic exposure meters (photoelectric type)*. In this new standard, it is mentioned that the APEX system has not been used on consumer products and accordingly it is not included in the standard

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[2] This is the adjective form of the word, pronounced "ar-ith-MET-ic".

[3] The degree sign here has nothing to do with angle. It was arbitrarily chosen to indicate the logarithmic form of the film speed rating.

[4] The reader may recognize that in the current ISO standard for film speed, both arithmetic and logarithmic forms are also defined. The relationship, however, is different that that of the ASA standard. ISO 100 (essentially equivalent to ASA 100) in ISO logarithmic form is "ISO 21°.

proper; however, because it has been found useful in engineering, it is included in an appendix for historical reference.

That standard was superseded by ISO Standard ISO 2720-1974, *Photography—General purpose photographic exposure meters (photoelectric type)—Guide to product specification*. The APEX system of notation is not covered by (or even mentioned by) this standard, nor is it covered by any other contemporary standard.

But the APEX system was given new life in the matter of the encoding of various photographic metadata items (aperture, shutter speed, etc.) in the metadata section of the "Exif"[5] standard for digital photographic images. It was decided that in the interest of most compact encoding, a logarithmic basis for encoding the various values was desirable, and, given that the APEX system existed, the Exif metadata scheme was based on APEX. This new life of APEX is covered by many standards, which I will not attempt to catalog here.

4 THE RELATIONSHIP OF THE TWO FORMS OF FILM SPEED

ASA PH2.5-1960 essentially says that the relationship of the two forms of film speed is given by this equation:

$$S^{\circ} = \log_2 NS \qquad (1)$$

where S° is the logarithmic form of the film speed, *S* is th arithmetic form of film speed, and N is a constant, said to be 0.30.

But elsewhere is it suggested that ASA 100 is to be considered exactly equivalent to ASA 5°, which relationship would imply K=0.32. The whole story there is curious and fascinating, but is beyond the scope of this article.

In any case, in the actual APEX system it is assumed that N=0.32

5 THE EXPOSURE METER CALIBRATION CONSTANTS

5.1 Introduction

International Standard ISO 2720-1974 prescribes a way of defining the "calibration" of a photographic exposure meter. By "calibration" is meant, for a given scene luminance (or, for incident light metering, illuminance) and a given stated film sensitivity, just what *photographic exposure* (combination of exposure time and aperture) the meter will recommend.

For reflected light metering, the calibration is defined by the *reflected light exposure metering calibration constant*, K.

[5] It is widespread but erroneous to refer to "the Exif" or "the Exif data" to mean the **metadata portion** of an image file, but of course "Exif" properly refers to an overall image file format (the Exchangeable Image File format).

For incident light metering, the calibration is defined by the value of the *incident light metering calibration constant*, C.

Note that the numerical values of these constants is affected by the unit used for luminance or illuminance involved in the relevant context. It is the usual practice today to state them as applies to the use of SI units for luminance or illuminance.

For both types of metering, a greater value of K or C means that, other factors being the same, the meter will give a greater exposure recommendation.

5.2 The exposure metering equations

5.2.1 *Reflected light metering*

The standard equation[6] for determining the "recommended photographic exposure" with reflected light metering (that is, based on measurement of the average luminance of the scene), is:

$$\frac{t}{A^2} = \frac{K}{BS} \qquad (2)$$

where t is the exposure time in seconds; A is the aperture, as an f/number[7] (these together comprising the "recommended photographic exposure"); B is the metered average scene luminance (brightness), in some appropriate unit[8]; S is the sensitivity (speed) of the film or digital imager, as an ISO speed number; and K is the *reflected light exposure metering calibration constant*.

Under the applicable standard, the value of K for an exposure meter may vary over a modest (explicitly stated) range. There is no inherently unique "proper" value, since the matter of "proper exposure result" is a subjective one at best. The manufacturer of a certain exposure meter model is free to choose a value of K (from within that range) to provide an exposure result the manufacturer believes will be considered "appropriate" by most users in most situations.

When we use values based on the logarithms of the various quantities (with the equation in this abstract context, any base for the logarithm will do here), we would expect that equation to become:

$$T_L - A_L = -B_L - S_L + K_L \qquad (3)$$

where the L subscript indicates that this is the logarithmic form.

[6] Given in ISO 2720-1974.

[7] The common scientific symbol for aperture as an f-number is N, but here I use A for consistency with the APEX exposure equation.

[8] The formal scientific symbol for luminance is L, but here I use B for consistency with the APEX exposure equation.

But the actual equation as prescribed for APEX is:

$$Tv + Av = Bv + Sv \quad (4)$$

Here Av, Tv, Bv, and Sv are the logarithmic counterparts of the terms in the original equation.

We may first note that several of the signs are now reversed from the earlier equation. The definitions of Tv, Bv, and Sv are such that they will have the proper sign to work in the APEX equation as shown above (and in fact will usually be all positive). This is in the interest in making the exposure equation "simple'.

But what happened to K? To make the APEX exposure equation really simple, a value of Kv has been "built into" the definition of Bv, so Kv does not appear at all.

What is the value of K that is built into the definition of Bv? In the basic definition of the APEX equation, no specific value is presumed or prescribed. It is assumed that each person using this equation would use the value of K that they would use in an actual exposure meter.

This of course is not really useful in a practical sense. So in the tables of Bv for various luminances (given in the APEX specification), a certain value of K is assumed. This is a value in the general area of that actually used by most existing exposure meters, but was precisely chosen so that for integral values of Bv, the corresponding luminance value (in the earlier, non-SI units) will be "tidy".

5.2.2 *Incident light metering*

The standard equation for determining the "recommended photographic exposure" with "incident light metering" (that is, based on measurement of the illuminance on the scene), is:

$$\frac{t}{A^2} = \frac{C}{I_S S} \quad (5)$$

where t is the exposure time in seconds; A is the aperture, as an f/number (these together comprising the "recommended photographic exposure); I_s is the metered illuminance on the scene, in some appropriate unit;[9] S is the sensitivity (speed) of the film or digital imager, as an ISO speed number; and C is the *incident light metering calibration constant*.

As for the constant C, the applicable standard allows it to vary over a modest (explicitly stated) range, under the same rationale as for K in the reflected light metering case.

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[9] The formal scientific symbol for illuminance is E, but here I use I for consistency with the APEX exposure equation.

When we use APEX values, this equation becomes:

$$Tv + Av = Iv + Sv \qquad (6)$$

For illuminance, whose normal scientific symbol is E, the APEX value has the symbol "Iv") ("I" for "illuminance").

The story as to the signs of the terms, is the same as for reflected light metering.

Note that here no logarithmic form of the calibration constant, C, is visible. As was done for K in the reflected light exposure equation, a certain value of C has been "built into" the definition of Iv. Again, the object is for the equation to be as simple as possible.

What is the value of C that is built into the definition of Iv? In the basic definition of the APEX equation, no specific value is presumed or prescribed. It is assumed that each person using this equation would use the value of C that they would use in an actual exposure meter.

Again, this not really useful in a practical sense. So in the tables of Iv for various illuminances (given in the APEX specification), a certain value of C is assumed. This is a value in the general area of that actually used by most existing exposure meters, but was precisely chosen so that for integral values of Iv, the corresponding luminance value (in the earlier, non-SI units) will be "tidy".

5.3 Discussion

It may seem odd (it is odd!) that the actual numeric values indicated by the APEX values Bv and Iv should depend on the choice of parameters (K, C) whose original use was to define the calibration of a photographic exposure meter. But keep in mind that the original objective of the APEX system was to facilitate the calculation that, on a complete photographic exposure meter, is done by the "exposure calculator" on the meter. And the concept of "not exactly standardized" values of K and C persisted in the APEX system

So, was the photographer using this new tool likely to have, for example, measured the illuminance upon the scene with a technical illuminometer (rather than a photographic exposure meter)? Probably not. More likely, he would work from a page in an article in a photo magazine that told, for various lighting situations (like "late afternoon sun"), what value of Bv should be assumed.

And so would the photographer have decided what value of C he "subscribed to"? Not likely.

So this story does not exactly work out. But because APEX never did come into widespread use by working photographers, many conundrums remained unresolved.

In any case, as we will see shortly, the tables typically used to relate values of the various exposure factors to their representation by APEX values are predicated on values of C and K that are chosen for a far more "pragmatic" reason: to make the tables have “tidy” values of the exposure factors (in their older, non-SI, units) for integral APEX values.

6 THE EQUATIONS AND TABULAR VALUES

6.1 Introduction

The following sections give the equations defining the various APEX values along with tables presenting the relationships between integer APEX values and the corresponding “numeric” values of the various factors. For Bv and Iv, there are no singular relationships; as was discussed above, the relationship is predicated on the essentially-arbitrary values of the meter calibration constants K and C that are assumed.

However, for those two quantities, the tables presented often published (such as the ones here) are predicated on specific values of K and C that make the values of the underlying quantities, for integral values of the APEX values, tidy[10]. Those values of K and C are stated with the corresponding tables.

6.2 The units

For Bv and Iv, the underlying quantities are presented in two units, the first being the “non-SI” unit and the second being the SI unit[11].

6.3 The numbers

In all the tables, integer values of the APEX value from 0 through 10 are shown. Of course, values outside that range (where practical) are valid, as are fractional values.

The values of the underlying quantity stated for each APEX value step are the exact ones (typically to 3 significant figures) given by the definition (in the case of Bv and Iv, for the value of K or C on which the table is predicated).

6.4 Pagination

I have started the section on each value on a new page in the interest of consistency.

6.5 The equations and tables

[Starts on the next page.]

[10] It is the “non-SI” unit values that are “tidy”, a result of the fact that when the APEX system was being introduced, the non-SI units for these qualities were the most widely used in US practice.

[11] SI refers to the International System of Units, the modern “metric system”. These units are preferred for technical and scientific work, but in practical photography, the “non-SI” units are still often used.

6.5.1 *Aperture value (Av)*

Aperture value (Av) represents the aperture in its f-number, form (*e.g.*, f/3.5). A larger Av represents a smaller aperture (larger f-number) and thus less exposure.

The formula defining Av is:

$$\mathrm{Av} = 2\log_2 A \qquad (7)$$

where A is the aperture as an f-number.

This table presents the (f-number) represented by integer values of Av. The number is the theoretical one for that Av. The number in square brackets it is the number rounded to the nearest one of the standard series of values for that quantity prescribed for use in photography, and is the "official" APEX number.

Aperture value (Av)	Aperture (A)
0	f/1.00 [1.0]
1	f/1.41 [1.4]
2	f/2.00 [2.0]
3	f/2.83 [2.8]
4	f/4.00 [4.0]
5	f/5.66 [5.6]
6	f/8.00 [8.0]
7	f/11.3 [11]
8	f/16.0 [16]
9	f/22.6 [22]
10	f/32.0 [32]

The factor 2 in the defining equation comes from the fact that exposure is proportional to the square of the aperture diameter.

The relationship is such that Av comes out positive for most values that would be encountered in practice (true of all APEX values).

Note that when speaking of the aperture in terms of the f-number as such in scientific work, a common symbol for the f-number is *N* (but this is far from universal). When working in the field of APEX, the symbol "*A*" is used (thus the APEX value symbol, Av).

6.5.2 *Time value (Tv)*

Time value (Tv) represents the exposure time (shutter speed) in seconds. A larger Tv represents a "faster" shutter speed and thus a lower exposure (it works in the same direction as the denominator of shutter speed).

The formula defining Av is:

$$\mathrm{Tv} = -\log_2 t \qquad (8)$$

This table presents the exposure time represented by integer values of Tv. The number is the theoretical one for that Tv. The number in square brackets it is the number rounded to the nearest one of the standard series of values for that quantity prescribed for use in photography, and is the "official" APEX number.

Time value (Tv)	**Exposure time (T) (sec)**
0	1
1	1/2
2	1/4
3	1/8
4	1/16 [1/15]
5	1/32 [1/30]
6	1/64 [1/60]
7	1/128 (1/125]
8	1/256 (1/250)
9	1/512 [1/500]
10	1/1024 [1/1000]

The minus sign in the defining equation is there to make Tv be positive for the values most often encountered in photography, and to make the APEX form of the standard photographic exposure equation work out with all plus signs,

6.5.3 *Speed value (Sv)*

Speed value (Sv) reflects the sensitivity of the film or equivalent, expressed as an "ISO speed". A larger Sv represents a greater sensitivity.

The formula defining Av is:

$$Sv = \log_2 \frac{S}{3.125} \quad (9)$$

where S is the "ISO speed" in arithmetic form.

This table presents the ISO speed represented by integer values of Sv. The number is the theoretical one for that Sv. The number in square brackets it is the number rounded to the nearest one of the standard series of values for that quantity prescribed for use in photography, and is the official APEX number..

Speed value (Sv)	Sensitivity (S) (ISO speed)
0	3.125 [3]
1	6.25 [6]
2	12.5 [12]
3	25
4	50
5	100
6	200
7	400
8	800
9	1600
10	3200

Here, the relationship given by the equation is not the obvious one. Rather it follows the relationship, in standard ASA PH2.5-1960, between the normal and logarithmic forms of the film speed rating (the latter being the progenitor of the APEX value, Sv) for the "standard" film speeds defined by the standard.

The equation in that standard, however, gives slightly different values of the speed for the integer APEX values (the difference being only about 0.093 stop).

6.5.4 *Brightness value (Bv)*

Brightness value (Bv) indicates the metered luminance (brightness) of the scene. A larger Bv represents greater scene luminance. The table shows the values of Bv on the basis of two different luminance units.

The formula defining Av is:

$$\mathrm{Bv} = \log_2 B \qquad (10)$$

where B is the luminance (brightness) in footlamberts. For luminance in cd/m^2, that becomes:

This table presents the scene luminance represented by integer values of Bv.

Brightness value (Bv)	Scene luminance (B), (brightness)	
	footlamberts	candelas/m^2
0	1	3.4
1	2	6.9
2	4	14
3	8	27
4	16	55
5	32	109
6	64	219
7	128	439
8	256	877
9	512	1754
10	1024	3508

As I discussed earlier, there is a value of K built into the definition of Bv. However, the value chosen for K, times another constant involved in the definition, comes to one (how handy!), so the relationship is not only "tidy" (for B in footcandles) but appears to be the obvious one. That value of K is 3.333 for luminance in footlamberts, 11.45 for luminance in candelas/m^2. [12]

The values shown for the unit footlambert are the precise theoretical ones. The values shown for the SI unit, candelas/m^2, are derived using the standard conversion between the two units to an appropriate precision.

[12] A K of 12.5 (for luminance in cd/m^2) is common today in actual exposure meters.

6.5.5 *Incident light value (Iv)*

Incident light value (Iv) indicates the (metered) illuminance (illumination) on the scene. A larger incident light value represents a greater illuminance. The table shows the values of Iv on the basis of two different units for illuminance.

The formula defining Av is:

$$Iv = \log_2 \frac{I}{6.125} \qquad (11)$$

where *I* is the incident illuminance (illumination) in footcandles.

Incident light value (Iv)	Illuminance (I) (illumination)	
	footcandles	lux
0	6.25 [6]	67
1	12.5 [12]	135
2	25	269
3	50	538
4	100	1076
5	200	2152
6	400	4304
7	800	8608
8	1600	17260
9	3200	34430
10	6400	68860

Here, the relationship is clearly not the obvious one (which would have been $Iv = \log_2 I$). That is because an assumed value of C is built into the definition of Iv.

In this case, that value could not be reasonably chosen to make the relationship the "obvious" one. But the specific value was chosen to make the I values (in footcandles) "tidy" for integral values of Iv. That value of C is 20.83 for illuminance in footcandles, 224.2 for illuminance in lux.[13]

The values shown for the unit foot-candle are the precise theoretical ones (and the value of C in the defining equation was chosen to make them "tidy"). In two cases, the official value, shown in square brackets, is rounded to an integer. The values shown here for the SI unit, lux, are derived using the standard conversion between the two units to an appropriate precision.

[13] A C of 250 (for illuminance in lux) is common today in actual exposure meters using a flat ("cosine") receptor, 340 for meters using a dome ("cardioid") receptor.

6.6 Exposure value (E_v)

The typical "reflected light" photographic exposure meter (the most commonly-used form by "hobby" photographers) measures (average) scene luminance (which we could state as B_v, an APEX value). This finding goes into some type of exposure calculator, typically a circular "slide rule", into which the photographer has set the sensitivity of the film or digital imager (as an ISO speed).

The calculator then presents a continuum of aperture versus shutter speed, any matching pair of which produce the exposure the meter "recommends" for the combination of scene brightness and film sensitivity.[14] The photographer makes a choice of a pair in order to suit the particular photographic task. The state of this calculator constitutes a value of Tv + Av, a number that we may say defines the recommended "photographic exposure".[15]

To facilitate discussions of this, APEX defines a composite value, Exposure Value (Ev), as:

$$Ev = Av + Tv \tag{12}$$

A larger value of Ev represents less exposure.

We can then rewrite the fundamental reflected-light metering exposure equation as:

$$Ev = Bv + Sv \tag{13}$$

Many light meters will in fact report their recommended exposure in terms of Ev as well as in aperture-shutter speed pairs.

6.7 Implications on assumed scene reflectance

If we compare the equations for reflected and incident light metering, using the embedded values for K and C, we conclude that they jointly imply that the reflective light meter operates on the basis of an assumed average scene reflectance of about 16%. But this matter is not that simple (owing to such matters as the inclusion of "overexposure headroom" in the reflected light metering strategy but not the incident light strategy).

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[14] This approach is based on an assumption of (a) average scene reflectance, (b) the range of reflectance from the darkest to the lightest object in the scene, and (c) a certain "strategy" for the resulting photometric exposure distribution.

[15] Called that to distinguish it from the quantity (best called "photometric exposure) that describes the total amount of "light energy" per unit area of the film (illuminance times time) as the result of the "shot"..

In any case, interpreting this relationship, and relating it to the "12.8%" and "18%" average scene reflectance values often mentioned in the theory of exposure metering standards, is a complex issue beyond the scope of this article.

7 SUNNY 16

Experienced photographers often use a "rule of thumb", sometimes referred to as the "sunny 16" rule, to estimate outdoor exposure when no meter is available. This rule suggests, for exposure on a scene illuminated by full sunlight[16], an aperture of f/16 and a shutter speed of one over the ISO speed number of the film (such as f/16 and 1/200 sec for ISO 200 film).

If we work backwards through the APEX incident light exposure equation, we find that this rule is essentially predicated on a scene illumination of about Iv 9.6, about 5000 footcandles (or about 50,000 lux).

8 EXPOSURE COMPENSATION – THE "Ev" SETTING

This topic is not really part of APEX, but it's a matter that is usually described in terms of an APEX value, so I will lightly treat it here.

Many cameras with automatic exposure capabilities have provision for forcing the camera to use an exposure that is greater or less, by a user-determined amount, than the exposure the metering system would normally choose. This is often useful for cases in which certain properties of the scene would frustrate the metering system's ability to secure the effect desired by the photographer.

An example is a scene where a large percentage of the image area has a very low brightness, or a scene where a large percentage of the image area has a very high brightness. The camera's metering system, left to its own devices, would call for an exposure that will cause these majority areas to be recorded as a nice middle gray for either scene.

The amount of this "exposure compensation" is often adjustable in steps of 1/2 or 1/3 "stop", often up to a maximum of 2 or 3 stops in either direction.

In effect, the use of this feature makes the basic exposure equation followed by the camera become:

$$\mathrm{Tv} + \mathrm{Av} = \mathrm{Bv} + \mathrm{Sv} - \mathrm{Xv} \tag{14}$$

where Xv is the exposure compensation setting in APEX-like units. (Note that Xv is not a term defined in APEX—it is my own notation.)

Thus, a "plus" setting of the exposure compensation control increases the exposure given for any given measured scene brightness (smaller values of Av and/or Tv produce greater exposure.)

[16] At some time of day, during some season, at some latitude—this isn't scientific, just handy!

The amount of exposure compensation is quite properly described in the same "units" as Ev. As a result, the exposure compensation setting is often called the "Ev setting". This is not a good description. It in fact does not set Ev, but rather forces the recommended Ev (even if only presented as a set of combinations of t and N) to be different from what would ordinarily be put into effect by the metering system. "Ev offset" is a better description. In technical contexts, exposure compensation is often called "exposure bias".

8.1 Scene brightness in Ev?

We often see, especially in camera specifications, a factor that seems to be scene luminance (brightness) but described in terms of an Ev number. Such a value might be given, for example, in stating the lowest scene luminance for which the exposure metering system of the camera is said to be able to function reliably.

The definition of this notation seems to be:

> The description of scene luminance is the Ev value that a reflected light exposure meter, observing that luminance, would give if the sensitivity was set to ISO 100.

This usage is unfortunate and technically inappropriate, as Ev is a measure of exposure, not luminance. There is a perfectly good APEX quantity for luminance: Bv. I suspect the motive for the practice is that many photographic enthusiasts have heard of Ev but not Bv.

On top of all this is that this notation is predicated on the "hypothetical exposure meter" having a certain value of K, the reflected light metering calibration constant, which value is never mentioned when this convention is used or discussed.

The relationship between this irregular description of scene luminance in "Ev" and the description of that luminance in the proper value, Bv, is as follows:

$$Bv = Ev' - 5 \qquad (15)$$

where Ev' is the so-called "Ev" used to describe the luminance.

I discourage this usage.

8.2 Ev "units" for everything

There is another practice which is not technically appropriate but doesn't actually give "wrong" information. Sometimes a camera manufacturer, stating the range of aperture available on a certain model, will say, for example: "f/2.8 through f/11, in 1/3 Ev steps". Of course, aperture is defined in terms of Av, not Ev. And APEX values are dimensionless and unitless, so a change in any one of them in the mentioned increment is just in steps of "1/3" (we might say, "1/3 unit", or even "1/3 APEX unit").

But, in defense of the practice, a 1/3 unit change in Av does give a 1/3 unit change in Ev. Perhaps the motive for the practice is that many photographic enthusiasts have heard of Ev but not Av.

Still, a better practice would be so say, if we feel we must state a "unit", "f/2.8 through f/11, in 1/3 stop steps". (*Stop* is widely used in photographic photometry as the "unit" of a change in a factor affecting, or relating to, exposure.[17])

8.3 Another caution

The author has seen a number of monographs and charts explaining APEX in which the concepts of *luminance* (brightness) and *illuminance* (illumination) were confused. Sometimes there will be a perfectly good Iv table labeled "Bv", or vice-versa. Sometimes discussions of *luminance* will mention the units that are applicable to *illuminance*, or vice-versa. Please be cautious before undertaking any strenuous intellectual exercise in this area where there is a risk of such misinformation.

This problem may well come about from the unfortunate similarity of the words for these two quite different quantities.

8.4 APEX notation for non-APEX quantities

Sometimes we will see it stated that in a particular situation, "Av was f/5.6" or "Tv was 1/60 sec". In fact, these APEX designations should only be used for the expression of these exposure factors in APEX (logarithmic) form.

A related problem occurs in connection with Canon cameras. Many of these have "aperture priority" and "shutter priority" exposure modes, in which the mentioned exposure factor is set directly by the user and the mating one is then set by the metering system to achieve the exposure (Ev) the system thinks appropriate. The two modes are labeled "Av" and "Tv", respectively. Yet the factors are set not in terms of APEX values but in conventional form ("f/3.5" or "1/125 sec"). What gives here?

Here's my guess: initially, on the Canon models offering these modes, the factors were indeed set in terms of the APEX units (in vogue at the time), and the modes were named correspondingly. Later, when awareness of APEX among photographers faded (or actually, didn't really flourish), Canon reverted to labeling the scales for setting aperture and shutter speed in the traditional units, but opted (for continuity) to retain the Av and Tv designations for the modes. Just a guess.

9 LIGHT VALUE, Lv

Sometimes we encounter what sounds like a related concept involving the quantity *light value* (Lv). What's with that?

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[17] However, in many standards and learned papers, the term "step" is used for an increment of 2:1 in an exposure factor (presumably "stop" was considered too colloquial). That sadly leads to such unfortunate locutions as, "The aperture may be set to f/2.8 through f/22, in steps of 1/3 step".

Today we mostly encounter this term as used by some authors as a replacement for "Ev" to unambiguously designate a logarithmic measure of scene luminance (the "Ev assuming ISO 100" convention). It's certainly better than calling the measure "Ev", but there is no need for this coinage, as a perfectly appropriate logarithmic measure of scene luminance exists: Bv.

There was an earlier use of the term "light value" (again symbolized as "LV"). On the first Polaroid Land camera, the Model 95, and the first "smaller film" Land camera, the Model 80, exposure was set with a single dial marked in terms of a number Polaroid called *light value*, symbolized LV. This is a logarithmic measure of exposure conceptually identical to exposure value (Ev) but with the scale starting at a different point (such that LV 1 = Ev 10).

The Polaroid exposure meter was set for the sensitivity (ISO speed) of the film in use, and then issued its exposure "recommendation" as an LV number. The user set this on the camera.

There was no provision for setting shutter speed and aperture separately. Each LV setting called up a preordained combination of shutter speed and aperture (an early example of "programmed exposure").

As the APEX system neared completion, Polaroid switched (in the successor models 95B and 80A) to the use of an Ev scale for exposure setting. This allowed consistency with other APEX-aware exposure meters, and the later Polaroid meters had Ev scales as well as LV scales (Ev scales only after a while).

Light value (LV), in either sense, is not part of APEX.

10 ABOUT "90TH BIRTHDAY SERIES"

This issue of this article is one of several publications made around the time of the 90th birthday of the author, May 8, 2026.

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