Designation: E312 – 06 (Reapproved 2011)

Standard Practice for
Description and Selection of Conditions for Photographing Specimens Using Analog (Film) Cameras and Digital Still Cameras (DSC)[1]

This standard is issued under the fixed designation E312; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Photographs are often used to convey information about the appearance of objects, materials, or phenomena involved in testing. The appearance of a photograph of an object depends not only on the appearance of the object, but on the conditions of formation of the optical image, the conditions of formation of the photographic record, and the conditions of viewing the photograph. If the photographic method of recording appearance is to be reproducible from one laboratory to another and if photographs of various specimens or one specimen at various times are to be used for valid comparisons, there must be an established method of describing pertinent conditions, so they may be recorded, communicated, and standardized. The purpose of this practice is to provide such a method of description.

1. Scope

1.1 This practice defines terms and symbols and provides a systematic method of describing the arrangement of lights, camera, and subject, the characteristics of the illumination, the nature of the photographic process, and the viewing system. Conditions for photographing certain common forms of specimens are recommended. Although this practice is applicable to photographic documentation in general, it is intended for use in describing the photography of specimens involved in testing and in standardizing such procedures for particular kinds of specimens. This practice is applicable to macrophotography but photomicrography is excluded from the scope of this practice.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1535 Practice for Specifying Color by the Munsell System

E284 Terminology of Appearance

E1360 Practice for Specifying Color by Using the Optical Society of America Uniform Color Scales System

E1541 Practice for Specifying and Matching Color Using the Colorcurve System (Withdrawn 2007)[3]

2.2 *ANSI Standards:*[4]

ANSI/ISO 517-1996 Apertures and Related Properties Pertaining to Photographic Lenses—Designations and Measurements

ISO 3664:2000 Viewing Conditions—Graphic Technology and Photography

ISO 18920:2000 Imaging Materials Processed Photographic Reflection Prints – Storage Practices

[1] This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.03 on Geometry.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

ISO 6846:1992 Black-and-White Continuous Tone Papers—Determination of ISO Speed and Range for Printing

3. Terminology

3.1 *Definitions*—Appearance terms used in this practice conform to definitions in Terminology E284. Terms related to photography conform to the cited standards of the American National Standards Institute.

4. Significance and Use

4.1 This practice provides a basis for choosing, specifying, recording, communicating, and standardizing the conditions and processes that determine the nature of a photographic image of a specimen. Its provisions are particularly useful when the photographic image is used to preserve or communicate the appearance of a specimen involved in an aging or stressing test that affects its appearance. It is often useful to compare photographs made under identical conditions before and after a test to illustrate a change in appearance.

4.2 This practice deals with specific details of camera technique and the photographic process, so it will probably be best understood and implemented by a technical photographer or someone trained in photographic science. The person requiring the photograph must clearly indicate to the photographer what features of the specimen are of technical interest, so he may use techniques that make those features clearly evident in the photograph, without misrepresenting the appearance of the specimen.

4.3 This practice provides useful guidance on presenting photographs for viewing, providing an indication of dimensions or scale, indicating the orientation of the picture, and referring to particular points on a picture. These techniques should be useful to those writing technical literature involving illustrations of the appearance of specimens. The methods of this practice should contribute materially to the accuracy and precision of other standards that rely on pictures to indicate various grades of some attribute of appearance, such as blistering or cracking.

4.4 For acceptance testing, manufacturing control, and regulatory purposes, it is desirable to employ measurement, but in those cases where there are no methods of measuring the attribute of appearance of interest, well-made photographs or photomechanical reproductions of them may be the best available way to record and communicate to an inspector the nature of the attribute of appearance.

5. Descriptors for Conditions

5.1 *Primary Points:*

5.1.1 *Central Image Point, I*—The geometrical center of the picture area on the film or plate, designated by the symbol *I* (see Fig. 1).

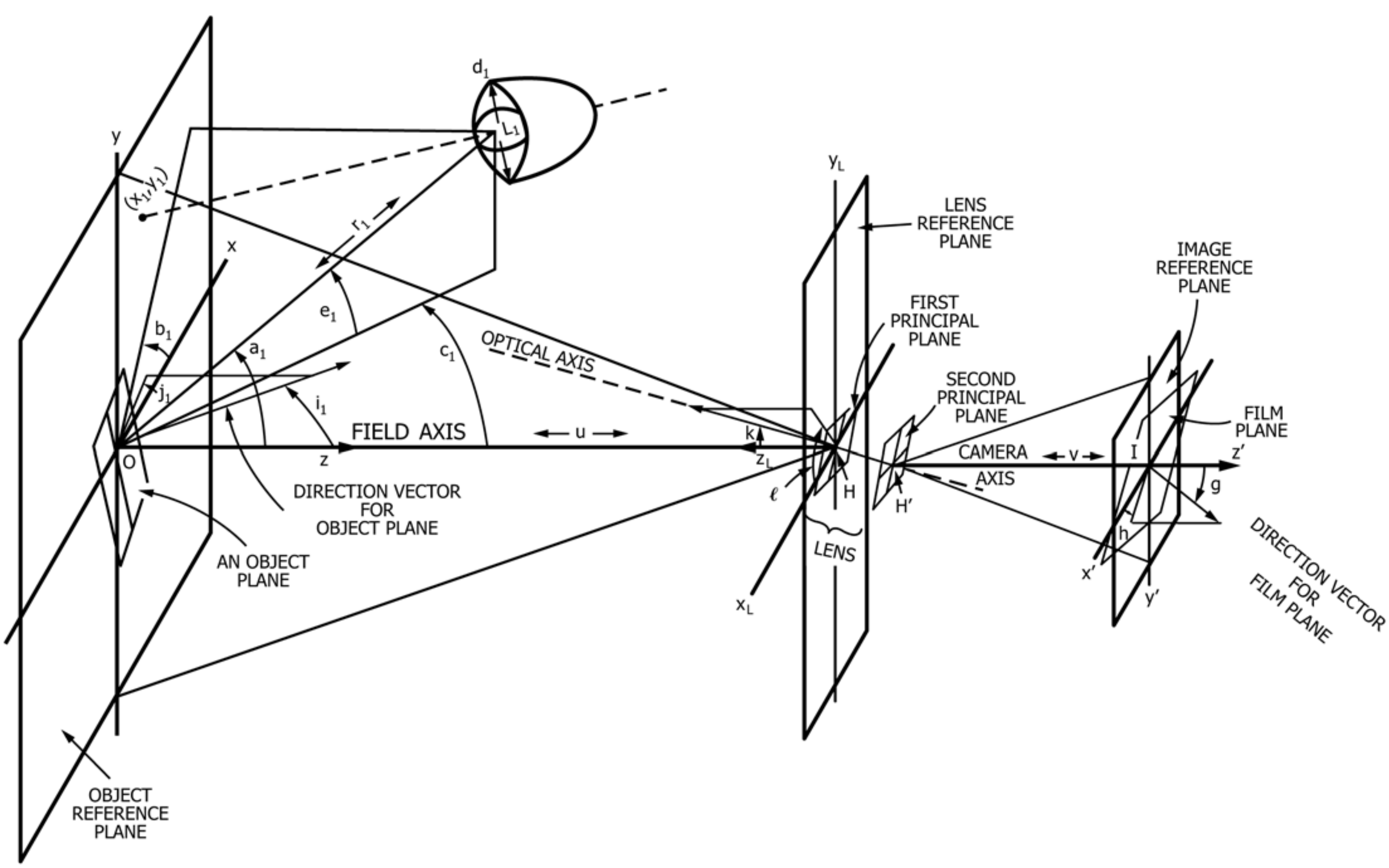

FIG. 1 Coordinate System for Specifying the Geometric Relationship of Camera, Subject, and Lighting

5.1.2 *Nodal Points, H, H'*—The two points *H* and *H'* in the lens system, located on the line joining the centers of curvature of the elements and having the property that any ray from the object directed toward *H* emerges from *H'* parallel to the original path. The nodal point with respect to rays from the object is called the "first nodal point" and is designated by the symbol *H* while the nodal point with respect to rays directed to the image is called the "second nodal point" and is designated by the symbol *H*.

5.1.3 *Central Object Point, O*—The point in the object space that is imaged at the central image point, designated by the symbol *O*. (It is not necessary that any material thing exist at this point.)

5.2 *Primary Axes:*

5.2.1 *Camera Axis*—The straight line between the central image point and the second nodal point. The distance between these points is called the "axial image distance" and is designated by the symbol *v*.

5.2.2 *Optical Axis*—The straight line joining the centers of curvature of the elements of the lens.

5.2.3 *Field Axis*—The straight line between the central object point and the first nodal point. The distance between these points is called the "axial object distance" and is designated by the symbol *u*.

5.3 *Reference Planes:*

5.3.1 *Image Reference Plane*—The plane normal to the camera axis, passing through the central image point.

5.3.2 *Lens Reference Plane*—The plane normal to the field axis, passing through the first nodal point.

5.3.3 *Object Reference Plane*—The plane normal to the field axis, passing through the central object point.

5.4 *Orientations:*

5.4.1 *Film Orientation*—The film or detector orientation is described in a right-handed orthogonal coordinate system having *x'* and *y'* axes in the image reference plane and *z'* axis on the camera axis, with the positive direction away from the lens. A film plane is described by the angles of a direction vector making an angle *g* with the *z'* axis and having a projection on the image reference plane making an angle *h* with the *x'* axis.

5.4.2 *Lens Orientation*—The lens orientation is described in a right-handed orthogonal coordinate system having x_L and y_L axes in the lens reference plane and z_L axis on the field axis, with the positive direction toward the object space. The x_L axis is parallel to the *x'* axis and the y_L axis is parallel to the *y'* axis. The lens orientation is described by the angles of a direction vector making an angle *k* with the z_L axis and having a projection on the lens reference plane making an angle *l* with the x_L axis.

5.4.3 *Object Orientation*—The object orientation is described in a right-handed orthogonal coordinate system having *x* and *y* axes in the object reference plane and *z* axis on the field axis, with the positive direction toward the lens. The *x* axis is parallel to the *x'* axis and the *y* axis is parallel to the *y'* axis. An object plane can be described in terms of the angles of a direction vector making an angle *i* with the *z* axis and having a projection on the object reference plane making an angle *j* with the *x* axis. Since an object plane may or may not pass through the central object point, the intersection of the plane with the *z* axis must be stated. If a cylindrical coordinate is found useful, the distance from a point to the *z* axis measured along the normal to the *z* axis may be designated by the symbol *p*. If there are a number of planes or points to be specified, they can be numbered and the coordinates given numerical subscripts accordingly, for example, x_1, x_2, x_3, i_1, i_2, p_1, p_2, etc.

5.4.4 *Illuminant Orientation*—The geometrical aspect of the illumination is described with respect to the same coordinate system used for describing the orientation of the object. The center or centroid of a light source is designated by the symbol *L*, with the appropriate subscript when more than one light source is used. The distance between the central object point and the center of a light source is designated by the symbol *r*, with the appropriate numerical subscript. The direction of the light from the point *O* is described in terms of the angles of a direction vector making an angle *a* with the *z* axis and having a projection on the object reference plane making an angle *b* with the *x* axis, or, alternatively, making an angle *c* with the *yz* plane (the angle *c* being positive on the positive *x* side) and an angle *e* with the *xz* plane (the angle *e* being positive on the positive *y* side). The diameter of the lamp reflector is designated by the symbol *d*, with appropriate subscript. The coordinates (*x, y*) of the point on the object reference plane toward which the lamp reflector is directed must be given. The size and shape of the lamp and reflector must be described with sufficient precision for the intended purpose.

5.5 *Spectral Nature of Illumination*—Incandescent lamps may be specified adequately by stating the kind of illuminant, the rated color temperature, and the electrical potential, in volts, at which the lamps are operated. The correlated color temperature of these lamps increases about 11 K for each volt increase in applied potential, in the neighborhood of 115 V. As lamps are used, the correlated color temperature (at a given voltage) decreases, often from 50 K above to 50 K below the rated value during the life of the lamp. Fluorescent lamps, arcs, and flash lamps differ more than incandescent lamps from black-body spectral emittance and must be described in detail as to make, model, type, etc. The nature of reflectors, including incidental nearby surfaces, can have an important effect on the spectral nature of the energy falling on the object. The neutrality of such surfaces should be specified when spectral quality is of interest.

5.6 *Contrast:*

5.6.1 *Object-Surround Contrast*—The appearance of an object may depend on the contrast between the object and the background or other visual surroundings against which the object is seen. The orientation of the background or surrounding materials may be described in the same way as the orientation of the object and the reflection characteristics of the materials appearing with the object may be completely specified. However, it is usually more convenient to specify the ratio of the luminance of the object to the luminance of the background or other surroundings, as measured from the direction of the camera lens by a photographic exposure meter. If constant contrast is desirable, it may be specified in that way but it should be noted that the use of constant contrast tends to minimize the visual appreciation of the variation of lightness among specimens.

5.6.1.1 If the object-surround contrast is specified for some standard object, it will vary from one specimen to another, according to the lightness of the specimen. A matte, neutral-gray card of specified reflectance may serve as the standard object. Such a neutral test card with a diffuse reflectance of 18 % on one side and 90 % on the other is sold by dealers in photographic supplies.[5] The placement of the test card in the object space must be specified.

5.6.2 *Illumination Contrast*—The appearance of an object may depend on the ratio of illuminances produced at the object by the various sources of illumination. This effect is most noticeable when surface texture is of interest. The ratios may be conveniently specified by the ratio of luminances produced by the sources separately on a matte, neutral-gray test card in the object space. The ratio of luminances can be measured with a photographic exposure meter. The exact value of the reflectance of the test card is immaterial for the purpose, as long as the card reflects enough light for accurate measurement. However, the surface must reflect diffusely. The placement of the test card in the object space and the point at which the measurement is made must be specified. Normally the card would be placed in the object reference plane and the measurement would be made at the point *O*.

5.7 *Polarization*—Unwanted specular reflections from the object are often avoided by the use of polarizers between the lamps and the object and a polarizing filter placed over the camera lens, or both. Since the use of such polarizers may have a pronounced effect on the appearance of an object as depicted, polarizers should be used in specimen photography only when required to depict the object most effectively, and in every case the usage should be clearly specified.

5.8 *Focal Length of Lens*—One of the principal characteristics of a photographic lens is its focal length (equivalent focal length), which is the distance measured along the optical axis from the second nodal point to the plane of best average definition when the camera axis, optical axis, and field axis are collinear and the axial object distance is more than 1000 times the axial image distance. The symbol for focal length is f. (See 7.3 for a discussion of the relationship between the focal length of the lens, perspective, and proper viewing distance.)

5.9 *Relative Aperture*—The relative aperture or f-number of a photographic lens is the ratio of the focal length to the diameter of the entrance pupil. Lenses are generally equipped with variable apertures to permit the adjustment of the illuminance of the image and the depth of field (see ANSI/ISO 517-1996). The relative aperture corresponding to each "relative aperture setting" is usually marked on the lens mount. When the object distance is short, as it often is in specimen photography, the image distance is somewhat greater than the focal length of the lens, and the illuminance of the image is less than it would be if the same object were photographed from a greater distance. The effective f-number, which takes the place of the marked f-number for exposure computations, is given by the following equation:

$$A' = (Av/f) \tag{1}$$

where:

A' = effective f-number,
A = marked f-number,
v = axial image distance, and
f = focal length of lens.

Since the depth of field is determined by the diameter of the entrance pupil, which can be computed from the focal length and the marked f-number, these quantities should be given whenever this determinant of image appearance is considered pertinent.

5.10 *Exposure Time*—The exposure time is the time interval during which light falls upon the film or plate. It may be determined by the action of a shutter or by the duration of the illumination (see **1-3**).[6] Since shutters require some time to open and some time to close and since light sources which determine exposure time may require time to reach the maximum intensity and time to reach zero intensity again, the illuminance at the image may be represented by a function of time. It may be necessary to specify this function when specifying the photography of objects very rapidly changing in relative orientation or optical properties with respect to time. For ordinary specimen photography, the exposure time is adequately specified by the "effective exposure time," which is the time during which a hypothetical instantaneously opening and instantaneously closing shutter would be open to admit the amount of light actually admitted by the shutter or, correspondingly, the time a hypothetical square-wave-pulse light source would be on to emit the same total luminous energy emitted by the actual source.

5.11 *Film or Plate*—Films and plates are generally specified by name of manufacturer, emulsion name, and the type of illuminant for which the film or plate is intended. Some films and plates are designated by special order numbers or type numbers. For the most precise specifications, requiring that sensitized materials used at various times or places be as nearly identical as possible, the batch number, known in photographic technology as the "emulsion number," must be specified and be the same in the various instances. In such cases, obtain the manufacturer's recommendations with respect to storage conditions to preserve the characteristics of the emulsion until it is used. In critical applications, particularly in color photography, it may be desirable to state the expiration date of the material, the date of exposure, and the date of processing.

5.12 *Chemical Processing:*

5.12.1 The processing of conventional photographic materials is generally specified by giving the following information about each bath in which the material is treated:

[5] Neutral-gray test cards having other reflectance factors may be obtained from the Munsell Color Laboratory, Macbeth Division, Kollmorgen Instruments Corp., 405 Little Britain Rd., New Windsor, NY 12553–6148.

[6] The boldface numbers in parentheses refer to the list of references appended to this recommended practice.

5.12.1.1 *Formula*—The formula may be given in terms of the amounts of various chemicals required to make 1 L of the solution, or reference may be made to the formula number stated in a given publication. All solutions shall be fresh and unused unless there are specific instructions to the contrary.

5.12.1.2 *Time in Bath*—The time should be specified within 4 %.

5.12.1.3 *Temperature of Bath*—The temperature of developing baths should be specified within 0.3°C (see ISO 6846:1992). The temperature of other baths should be specified within 1.1°C.

5.12.1.4 *Type of Agitation*—The type of agitation may be described in terms of the equipment and its manipulation with respect to time. For the most exacting work, requiring the utmost in uniformity of processing on a given sample and reproducibility from sample to sample, recourse must be had to sensitometric processing (see ISO 6846:1992(**4**)).

5.12.2 For materials processed in the camera, the processing is specified by the temperature and time of processing.

5.12.3 An alternative to the specification of time, temperature, and agitation is the specification of the degree of development by specifying the "gamma" to which the material is processed. The gamma is the slope of the straight-line portion of the plot of density against the logarithm to the base 10 of the exposure (**1**). The measurement of gamma requires the use of a special exposure device and a densitometer, which are not always available to the photographer. It is often useful to include a "gray scale," that is, a series of small patches of known diffuse reflectance factors in the picture. In this way, the tones of the picture may be interpreted in terms of reflectance factors on the original object by comparison to the gray scale. If quantitative comparisons are to be made, the images of the patches must be large enough to be measured with the available densitometer.

5.13 *Print Material and Processing*—For display or publication, a print of the original negative or positive photograph may be made. The printing material may be specified by manufacturer and emulsion name or other appropriate designator as suggested for specifying the original material. In the case of printing papers, the color of the paper, the kind of surface, and the "grade" or "contrast" of the paper used should be given. To minimize the influence of the kind of surface on the appearance of the image, a glossy material should be used and the print should be dried in the usual manner for such materials, in contact with a highly glossy surface, to produce a uniform glossy surface on the print. If a variable-contrast paper is used, the printing filter and illuminant should be specified. If an enlarger is used, the type (condenser or diffuser) should be stated. The processing of the print may be specified in the same manner as the processing of the original material.

5.14 *Stability of Image*—If the photographic image changes in time, comparisons of the appearance of specimens from one time to another by means of photography may be misleading. Storage conditions can have a pronounced influence on the stability of photographic images. ISO 18920:2000 provides recommended practices.

5.15 *Electronic Image Detectors*—Digital cameras capture images using solid-state electronic detectors rather than chemically-processed photographic film. Several technologies are in common use, including charge-coupled device (CCD) and complimentary metal-oxide semiconductor (CMOS). Features significant to the quality of the image produced include the number of picture elements ("pixels") captured by the detector, its photographic speed, and subsequent digital processing.

5.16 *Digital Image Processing*—Digital processing provides many degrees of freedom for altering an image. Dynamic range, contrast, color reproduction, sharpness, and other parameters may be readily changed by commercially-available computer software as well as by software or firmware within the camera.

5.16.1 *Image Compression*—Many cameras employ compression algorithms to reduce the amount of data that must be transmitted or stored to encode an image. Unless the algorithm is lossless, the decompressed result will differ from the initial version. The differences may be invisible, or they may result in discernible artifacts. The type of compression and its parameter settings should be recorded.

5.16.2 *Image Sharpness*—Image sharpness may be reduced by any of several blurring algorithms or increased by sharpening. Blurring algorithms average data from several pixels at a time and thus act to reduce the information content of an image. Sharpening may appear to make features of the image more visible, but it can not increase the information content. Oversharpening may introduce visible artifacts. Details of any blurring or sharpening operations should be specified.

5.17 *Reproduction of Tone and Color:*

5.17.1 One would expect that elements of a photograph would have the same luminances relative to one another as the elements of the original scene. The luminances as measured without flare, however, are usually adjusted to take account of flare present in all real-life viewing conditions. Other adjustments may be made to take account of differences in luminance of the surround. Systematic alterations of hue and saturation may also be present. Careful documentation of all the details of image capture and processing is required to enable another investigator to accurately recreate photographs of a scene. Including a standard object in the scene provides a ready reference for such documentation. The simplest standard object is a neutral gray test card, discussed in 5.6.1.1. It provides a tie point connecting one specific scene luminance with its corresponding luminance on the photograph. A standard object containing a series of neutral areas from black to white profiles documentation of contrast as well, as described in 5.12.3. A standard object containing a variety of colored areas in addition to a neutral series allows documentation of the color reproduction properties of the system. Color charts for this purpose are commercially available, or they may be created by selecting specimens from collections that represent various color order systems; see, for example, Practices D1535, E1541, or E1360.

5.17.2 The use of color charts produced by photography or printing is not recommended as standard objects for the purposes of this standard. These color charts derive all their neutral and colored patches from combinations of a limited set of three or four colorants. Observer metamerism may therefore exist between the colors of these patches and equivalent colors in the scene; of particular concern is the metamerism between a human observer and the camera or film used to photograph the scene. Specimens from the collections referenced above, on the other hand, tend to be spectrally non-selective, especially the neutral specimens; this significantly reduces the amount of metamerism likely to be encountered.

5.18 *Viewing Conditions*—The conditions under which a photograph is viewed can be specified by means of the same methods used to describe the arrangement of object, lights, and camera by considering the picture as the object, and by placing the eye rather than the camera lens at the point of view. The spectral nature of the illumination may, likewise, be specified as before.

5.18.1 For critical applications, the viewing conditions should conform to the specifications of the pertinent ISO Standard (ISO 3664). Viewing booths providing conditions conforming to that standard are commercially available and are commonly used in photography and in the control of printing with ink.

6. ASTM Standard Conditions

6.1 *ASTM Standard Camera Alignment*—A camera is in ASTM Standard Camera Alignment when the optical axis and the camera axis are collinear and the film surface is in the image reference plane. These conditions may be stated briefly as follows: $k = 0$; $g = 0$. Simple cameras without swings are made in this alignment. Studio cameras are aligned in this way when neither the lens board nor camera back are swung, tilted, raised, or lowered from their normal positions.

6.2 *ASTM Standard Specimen Orientations:*

6.2.1 *ASTM Standard Orientation No. 1 for a Plane Surface*—A plane surface specimen is in ASTM Standard Orientation No. 1 if the surface is normal to the field axis with the normal to the surface in the direction of the positive z axis. The camera is "aimed directly at" the surface. In this orientation, the surface is in the object reference plane and the angle i to the surface normal is 0. In this case the surface is in the xy plane and may be described by the equation $z = 0$.

6.2.2 *ASTM Standard Orientation No. 2 for a Plane Surface*—A plane surface specimen is in ASTM Standard Orientation No. 2 if the normal to the surface is at an angle $i = 45°$ to the z axis and its projection on the object reference plane is at an angle $j = 0$ to the x axis. In this case the surface is in the plane described by the equation $x = -z$.

6.2.3 *ASTM Standard Orientation No. 3 for a Plane Surface*—A plane surface specimen is in ASTM Standard Orientation No. 3 if the surface is in the yz plane. In this case the surface is in the plane described by the equation $x = 0$.

6.2.4 *ASTM Standard Orientation No. 1 for a Sphere*—A spheric specimen is in ASTM Standard Orientation No. 1 if its center is at the point O. The center is at the point (0, 0, 0).

6.2.5 *ASTM Standard Orientation No. 2 for a Sphere*—A spheric specimen of radius R is in ASTM Standard Orientation No. 2 if the center is on the z axis at a distance R in the direction of the negative z axis. The center is at the point $(0, 0, -R)$.

6.2.6 *ASTM Standard Orientation No. 3 for a Sphere*—A spheric specimen of radius R is in ASTM Standard Orientation No. 3 if the center is on the y axis at a distance R in the direction of the negative y axis. The center is at the point $(0, -R, 0)$.

6.2.7 *ASTM Standard Orientation No. 1 for Right Circular Cylinder*—A right circular cylindrical specimen of radius R and height J is in ASTM Standard Orientation No. 1 if the axis of the cylinder is on the z axis and the end facing the camera is in the object reference plane. The surface of the idealized cylinder is described by the equations $x^2 + y^2 = R^2$ and $-J\ z\ 0$.

6.2.8 *ASTM Standard Orientation No. 2 right circular cylindrical specimen is in ASTM Standard Orientation No. 2 if the axis of the cylinder lies in the positive* x and z quadrant of the xz plane, and passes through the point O at an angle $i = 45°$ to the z axis. The axis lies on the line described by the equations $x = z$ and $y = 0$.

6.2.9 *ASTM Standard Orientation No. 3 for a Right Circular Cylinder*—A right circular cylindrical specimen is in ASTM Standard Orientation No. 3 if the axis of the cylinder is on the x axis. The cylindrical surface is described by the equation $y^2 + z^2 = R^2$.

6.2.10 *ASTM Standard Orientation No. 4 for a Right Circular Cylinder*—A right circular cylindrical specimen of radius R is in ASTM Standard Orientation No. 4 if the axis of the cylinder is parallel to the x axis and passes through a point on the negative z axis at a distance R from the origin, O. The cylindrical surface is described by the equation $y^2 + z^2 + 2zR = 0$.

6.2.11 *ASTM Standard Orientations to Exhibit One Face of a Cuboid* (Note 1)—If the length, width, and height of a cuboid are all different, the solid has faces of three different areas which may be designated A, B, and C in descending order of area. A cuboid is in ASTM Standard Orientation:

6.2.11.1 A if the visible face A is in the xy plane, centered at the origin, O , with its long side parallel to the x axis,

6.2.11.2 B if the visible face B is in the xy plane, centered at the origin, O, with its long side parallel to the x axis, and

6.2.11.3 C if the visible face C is in the xy plane, centered at the origin, O, with its long side parallel to the x axis.

NOTE 1—A cuboid is a solid bounded by rectangular faces, represented by an ordinary brick or packing box. Other names for such a solid are: rectangular polyhedron, rectangular hexahedron, rectangular parallelepiped, and right rectangular prism.

6.2.12 *ASTM Standard Orientations to Exhibit Two Faces of a Cuboid*—Using the symbols A, B, and C as defined in 6.2.11,

TABLE 1 ASTM Standard Orientations to Exhibit Two Faces of a Cuboid Having Faces A, B, and C

Standard Orientation	AB	AC	BA	BC	CA	CB
The two opposite faces designated by this symbol are centered on x axis equidistant from origin O	C	B	C	A	B	A
The normal to this visible face is at an angle of 30 deg to the positive y axis	B	C	A	C	A	B

TABLE 2 ASTM Standard Orientations to Exhibit Three Faces of a Cuboid Having Faces A, B, and C

Standard Orientation	ABC	ACB	BAC	BCA	CAB	CBA
The normal to this visible face is at an angle of 15 deg to the positive *y* axis	C	B	C	A	B	A
The normal to this visible face is at an angle of 30 deg to the positive *x* axis	B	C	A	C	A	B

a cuboid is in the standard orientation indicated in Table 1 when it is centered at the origin, *O*, and the indicated conditions are met. It may be noted that the orientation designators name the two faces exhibited, the first named being viewed more nearly directly.

6.2.13 *ASTM Standard Orientations to Exhibit Three Faces of a Cuboid*—Using the symbols A, B, and C as defined in 6.2.11, a cuboid is in the standard orientations indicated in Table 2 when it is centered at the origin, *O*, and the indicated conditions are met. It may be noted that the orientation designators name the faces exhibited in the order: most directly viewed, less directly viewed, least directly viewed.

6.3 *ASTM Standard Lighting Arrangements:*

6.3.1 *ASTM Standard Lighting Arrangement No. 1, Diffuse Front Lighting ("Flat" Lighting)*—Light falls upon the front of the object uniformly from nearly all angles *b* from 0 to 360° and angles *a* from near 0 to 90°. Such lighting emphasizes tones and deemphasizes form and texture. Modeling is weak because there are virtually no shadows.

6.3.2 *ASTM Standard Lighting Arrangement No. 2, Diffuse Back Lighting (Transillumination or "Silhouette" Lighting)*—Light falls upon the back of the object uniformly from essentially all angles *b* and 0 to 360° and angles *a* from 90 to 180°. Such lighting is obtained by placing a uniformly bright diffuse illuminator or illuminated plane diffuse reflecting surface behind the object. Such lighting emphasizes the profile and translucent aspects of the specimen but obscures front surface detail.

6.3.3 *ASTM Standard Lighting Arrangement No. 3, Modeling Light Only*—A single source, L_1, is located above and to one side of the field axis. Angle $c_1 = 45$ deg, angle $e_1 = 45°$, the ratio of distance to diameter, r_1/d_1, is between 5 and 10, and the lamp is directed toward the origin, *O*. This lighting reveals front surface form but produces harsh shadows.

6.3.4 *ASTM Standard Lighting Arrangement No. 4, Modeling and Fill-in Lighting*—The modeling light specified in Standard Lighting Arrangement No. 3 is used with a fill-in light, L_2, to the other side of the field axis. Angle $c_2 = -10°$, $e_2 = 0$, the ratio of the distance to diameter, r_2/d_2, is between 3 and 5, and the lamp is directed toward the origin, *O*. The illuminance produced by the modeling light should be four times that produced by the fill-in light, measured as described in 5.6.2. If the lamps are of equal power and broadly diffused, $r_2 = 2r_1$, approximately. This is the simplest general-purpose lighting to produce good modeling but render detail in the shadows.

6.3.5 *ASTM Standard Lighting Arrangement No. 5, Side Lighting*—A single light is located on the positive *x* axis. Angle $c = 90°$, angle $e = 0$, the ratio of distance to diameter, r/d, is between 5 and 10, and the lamp is directed toward the origin, *O*.

6.3.6 *ASTM Standard Lighting Description*—Any number of lamp locations, subtenses, and directions can be enumerated conveniently in the form of a table such as Table 3. In critical applications each lamp and reflector must be described, and in every case one should give the relative illuminance produced by each lamp alone on a neutral-gray card held at the object and normal to the lamp beam direction, as measured with a photometer or exposure meter. In general, adjustable spotlights produce patterns of illumination that are difficult to describe and reproduce. Self-contained reflector-spot lamps may be described adequately for most purposes by the methods of this section.

7. Conventions for Exhibiting and Publishing Photographs of Specimens

7.1 *Scale Indication*—Parts of a photographic image may be the same size as the corresponding parts of the object, larger, smaller, or even a complex combination of these when an object is depicted in perspective. Thus, it is necessary to indicate the scale of the photograph to convey an accurate impression of the size of the object photographed. Indicating the scale by stating the magnification has two disadvantages. First, the photograph may be copied or printed for publication at a different scale, changing the magnification. Similarly, the picture may be projected in an auditorium, in which case the concept of magnification can be very confusing. Secondly, the magnification may differ considerably from one part of a picture to another, depending on the various object distances. If the object is in a plane normal to the field axis, the camera is in standard alignment, and one can neglect the distortion of the lens, the scale is constant, and can be indicated by displaying a graduated line in the plane of the object in the photograph. Subsequent reductions and enlargements then carry the correct scale indication. This procedure requires some preparation before the picture is taken or artwork afterward. The scale of three-dimensional objects is best given by stating in a caption the dimensions of enough aspects of the object to give an accurate impression of scale. This procedure is recommended as a general practice because it overcomes all the difficulties noted above.

7.2 *ASTM Standard Orientation Mark*—Since photographs of test specimens often display no inherent indication of orientation, an orientation mark is recommended for inclusion in the original photograph or application afterward. Inclusion in the original photograph should be useful in cases where the orientation is important to a test program, it is not otherwise obvious from the photograph, and it cannot be determined later.

TABLE 3 Example of Tabular Description of Lighting Arrangement

Lamp Number	*c*, deg	*e*, deg	*d*, in.	*r*, ft	*x*, in.	*y*, in.
1	45	45	10	5	0	0
2	−10	0	12	4	0	0
3	150	30	3	4	−6	8

The ASTM Standard Orientation Mark shall be in the form shown in Fig. 2 and it shall be placed in the lower lefthand corner of the picture with the apex upward. This convention agrees with the existing convention of placing a "thumb mark" on the lower left corner of a slide mount as an aid to projectionists, a practice which this convention is not intended to supplant. This form is self-explanatory and possesses sufficient asymmetry to provide unique orientation even on a square transparency. It is an equilateral triangle three units on a side joined to a square one unit on a side. It may be used in any appropriate size or color.

7.3 *Perspective and Proper Viewing Distance*—The location of the first nodal point of the lens, *H*, with respect to the object may be called the "point of view." It determines which parts of the object are visible and which parts are hidden by other parts. The total "perspective," including these factors, the angles between the projected images of various lines on the object, and the relative proportions of various parts of the image, depends on the point of view and the relative orientation of the lens and film as determined by what are known as camera "swings" (**5**).

7.3.1 It is commonly believed that the focal length of the lens determines the perspective. This belief arises from the fact that several photographs on the same size film, taken with lenses of different focal lengths but covering the same field of view, do have different perspective. The perspective differs because, to cover the same field of view in all cases, it is necessary to assume points of view at different distances from the subject. If the same point of view were used in all cases, a lens of longer focal length would project a larger image and the film would subtend a smaller field of view but the perspective would remain constant.

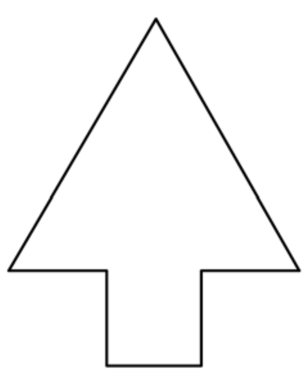

FIG. 2 ASTM Standard Orientation Mark (to be placed at the lower left-hand corner of photographs to provide a means of establishing orientation)

7.3.2 Correct perspective is presented to the eye when a contact print is viewed with the eye the same distance from the print as the lens (point *H'*) was from the film when the original exposure was made and with the normal to the point making an angle with the viewing axis equal to the angle between the normal to the film and the camera axis during the original exposure. If the picture is enlarged, the proper viewing distance is magnified in the same ratio as the length or width. When an accurate representation of spatial relationships would enhance the value of a photograph, the proper viewing distance can be given in terms of a number of units based upon some dimension in the picture, for example, "Proper perspective will be obtained if the photograph is viewed at a distance ten times the length of the image of the blade." Such a statement will be true at any magnification. Since the normal eye cannot comfortably accommodate at very short distances, viewing at distances less than about 6 in. (150 mm) usually requires the use of a lens of focal length equal to the viewing distance. If the need for a lens is to be avoided, the picture should be enlarged so the proper viewing distance exceeds 6 in.

7.4 *ASTM Standard Coordinate System for Pictures*—To provide a standard coordinate system on the basis of which one may refer to various points on a picture, the following system is defined. This coordinate system shall be called the ASTM Standard Coordinate System for Pictures: the origin is at the center of the picture, the positive *x* axis is directed to the right, the positive *y* axis is directed upward, and the length scale is normalized so that the maximum ordinate or abscissa on the picture is 1.00. For example, on a picture 160 mm high and 200 mm wide, *x* ranges from −1 to +1 and *y* ranges from −0.8 to +0.8. References to points on the picture based on such a normalized scale are valid for any magnification or reduction.

8. Keywords

8.1 analog camera; digital still camera; DSC; lighting; photography; viewing

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