4.2 The density readings of the exposed and processed sample may now be plotted against the actual step tablet densities.

4.3 For laboratories using graph paper where the horizontal co-ordinate is shorter than the vertical co-ordinate: on graph sheets where the horizontal co-ordinate carries 7½ equal divisions between each "step" or log exposure reference, each division represents 0.02 density of the sensitometer step tablet and may be used as reference to plot the densities of the step tablet against the densities of the exposed and processed sample.

4.4 Where there is no scale on the horizontal co-ordinate between each "step" or log exposure reference, a scale may be drawn to divide the space between each reference into 7½ equal parts. Each part will represent 0.02 density of the sensitometer step tablet. This scale may be moved up the sheet opposite the various density readings of the exposed and processed sample so as to locate the step tablet densities versus the processed sample densities.

5. *Care of the Modulator*

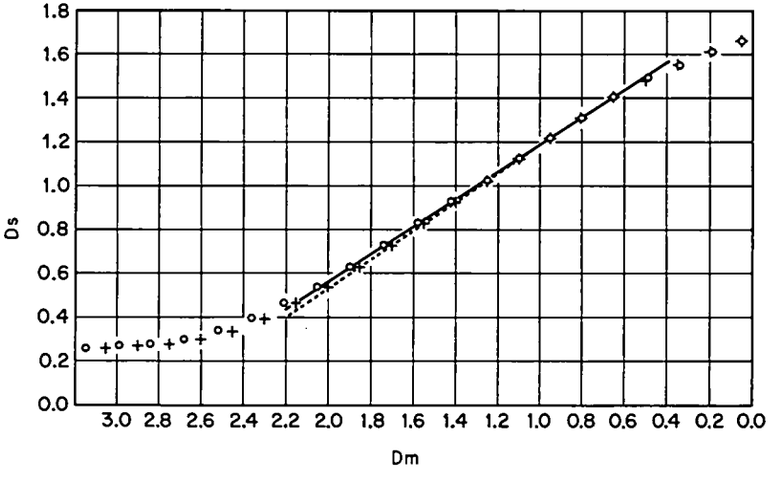
5.1 Step tablets are very delicate. To prevent damage, it is customary to protect the tablet with a thin, transparent acetate cover. The surface of the cover should be inspected from time to time to ensure that it is clean and free from abrasion. The acetate cover should be renewed when necessary to ensure that the diffuse transmission densities of the modulator steps are not affected by dirt or abrasion on the cover.

5.2 While the density of step tablets normally changes little over periods ranging up to two years, it is suggested that they be checked for density from time to time.

## Appendix

(The Appendix is not a part of this SMPTE Recommended Practice, but is included for information purposes only.)

The graph paper described in this recommended practice is in accordance with SMPTE Recommended Practice RP 22-1966, Specifying Graph Paper Used in Inter-Laboratory Exchange of Plotted Sensitometric Data. In plotting sample density against actual step tablet density, the density scale along the horizontal co-ordinate is equivalent to the log E scale; e.g., 0.02 density equals 0.02 log E. Following this procedure, comparisons of plotted sensitometric data can be made with the knowledge that any observed differences cannot be attributed to differences in the plotting method.




**Legend**

---x---x Curve showing sample densities versus modulator densities assumed to have consecutive ideal increments of 0.15

—o—·—o— Curve showing same sample densities versus actual modulator densities for a modulator not meeting the criterion of 3.3 (2)



# SMPTE RECOMMENDED PRACTICE

# RP 15-1982

## *Calibration of Densitometers Used for Black-and-White Photographic Density Measurement*



1. *Scope*

1.1 The purpose of this recommended practice is to specify the means to be employed in the calibration of densitometers utilized in the measurement of diffuse transmission densities.

1.2 This practice applies to densitometers utilized for the measurement of processed black-and-white photographic films and plates or cast colloidal carbon tablets.

2. *Types of Densitometers*

2.1 In general, only those densitometers which conform to the geometric and spectral conditions specified by American National Standard Conditions for Diffuse and Doubly Diffuse Transmission Measurements (Transmission Density), ANSI PH2.19-1976, are capable of giving accurate readings of American National Standard diffuse transmission density for all types of black-and-white photographic materials.

2.2 If a nonconforming densitometer is to be used with a given type of photographic material, it may be calibrated from reference samples composed of the same material. In this way, any densitometer may be calibrated to read "American National Standard Diffuse Transmission Density," Type V(λ) or Type $P_3(\lambda)$, on any single type of photographic material to a degree of accuracy commensurate with the stability and reproducibility of the instrument itself. In general, a new calibration must be made to obtain accurate readings on a different material when a nonconforming densitometer is used.

3. *Reference Specimen*

3.1 A reference specimen shall be a calibrated gray scale which is stored with special care and used at intervals of three months, more or less, as a primary reference against which to control the working specimens. (See 4.1.)

3.2 A densitometer conforming to the geometric and spectral conditions specified in ANSI PH2.19-1976, for either Type V(λ) or $P_3(\lambda)$, and measuring in American National Standard diffuse transmission density, shall be used to calibrate the reference specimen. (Calibrated reference specimens are sold by manufacturers of densitometers, sensitometers and film.)

3.3 The reference specimen shall have a range of diffuse transmission densities from below 0.06 to 3.0 or greater.

3.4 The density variation within each step or within each specified calibration area shall be 0.01 or less. (Care should be exercised in selecting reference specimens. They should be free from dirt spots and abrasions. The step or calibration area should be large enough to accommodate the largest aperture used for measuring the specimen and to allow for normal specimen-positioning variations. Good optical density stability is essential for reference specimens. In general, this can be accomplished by keeping the processed specimen two months or longer under normal laboratory lighting and temperature conditions before calibrating the specimen.)

3.5 A calibration chart shall accompany each reference specimen, giving the diffuse transmission densities of each step. It shall be noted on the calibration chart whether the diffuse transmission densities listed are American National Standard diffuse visual densities Type V(λ) or American National Standard diffuse printing densities Type $P_3(\lambda)$ (ANSI PH2.19-1976). Each reference specimen and corresponding calibration chart shall be identified by a code or serial number. The chart shall also show the type of film of which the reference specimen is made.

3.6 Each step of each of three reference specimens shall then be measured carefully on the laboratory densitometer to be controlled. The step-by-step measurements of one specimen shall be compared to the calibration chart values for that specimen, and the deviations* plotted versus the calibration chart values. Measurements of each of the other specimens shall also be compared to corresponding calibration values, and the deviations plotted upon the same chart (Appendix). This procedure establishes the correlation among reference specimens.

* If, during the procedure, deviations in excess of the tolerances shown in 3.2 are obtained, the densitometer first could be recalibrated according to Section 5 and the procedure repeated. However, correlation curves obtained from a densitometer out of calibration (but operating properly) are valid.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3.7 The procedure in 3.6 shall be repeated on the same densitometer at three-month intervals. If the correlation among reference specimens remains the same, it can be assumed that the specimens have not deteriorated. (Even if used once a week for calibration, seasoned (see 3.4 footnote) reference specimens, when properly handled, might be expected to remain in good condition for about a year.)

3.8 If the trimonthly check reveals that one specimen no longer correlates with the others, it shall be discarded. If the trimonthly check shows that the samples have maintained their original correlation but all three deviation curves have shifted, it may be assumed that the instrument calibration has changed. (However, it is remotely possible that all reference specimens have deteriorated equally.)

4. *Working Specimen*

4.1 A working specimen shall be a calibrated gray scale which is used for the routine calibration of densitometers and measured for correct density against the reference specimens at intervals of three months, more or less.

4.2 For routine checking of the densitometer, it is not advisable to use the reference specimens. For this purpose, working specimens of the same material shall be used once they have been related directly or indirectly to the reference specimens.

4.3 The working specimen can be directly related to the reference specimens by deviating initial average of replicate readings of the working specimen from those of a reference specimen calibration curve (3.6). These deviations, when plotted, shall constitute a working specimen calibration curve. The tolerances shown in 5.2 shall apply to the step values assigned to the working specimen.

4.4 The following alternate technique may be used in place of that outlined in 4.3: a working specimen may be selected and the step densities read on a densitometer which has been newly calibrated by means of the reference specimens. When this working specimen is subsequently used to check densitometer calibration, the instrument shall duplicate the original readings within a tolerance of ± 0.01 from density 0.00 to 2.0 and within ± 0.02 above a density of 2.0. (These tolerances apply to electronic physical densitometers such as the Westrex or Eastman Electronic densitometer. Other densitometers may require wider tolerances. See note after 5.2.) If this tolerance is exceeded in the same direction by three successive steps in one calibration check or by one step on three successive calibration checks, the instrument shall be evaluated with reference specimens. If this evaluation shows the instrument to be in calibration, the new density values shall be assigned to the working specimen, or the working specimen shall be replaced by a new one. If, however, the reference specimen confirms that the instrument is out of calibration, it shall be recalibrated, as in Section 5.

5. *Densitometer Calibration*

5.1 The reference specimen shall be placed in the densitometer to be calibrated in the manner specified in ANSI PH2.19-1976; i.e., the emulsion side of the reference specimen shall face the receiver, except that if the incident radiation is diffuse, the emulsion side of the specimen shall face the diffuser. (Reference specimens should be handled with care to prevent density changes resulting from abrasions, fingerprints or foreign materials such as grease or film-cleaning compounds.)

5.2 The values of diffuse transmission density of the type desired indicated by the densitometer under test shall agree with the values shown on the calibration chart accompanying the reference specimen. For routine sensitometric applications, tolerances may be allowed as follows:

| *Density* | *Tolerance* |
|---|---|
| 0.0 to 1.0 | ± 0.01 |
| 1.0 to 2.0 | ± 0.015* |
| 2.0 to 3.0 | ± 0.02 |
| 3.0 to 4.0 | ± 0.03 |

Each individual densitometer will vary about its bias level. The amount of variation will depend upon the type and condition of the instrument. Precision or repeatability of individual densitometers will determine the need for and degree of replication of measurements.

5.3 A densitometer which gives measured values with the reference specimen in excess of the tolerance in 5.2 shall be taken out of service for repair or adjustment. Alternatively, a correction table or chart may be utilized to permit adjustment of the measured values in accordance with the calibration chart.

5.4 If the densitometer under test is of the nonconforming type, its scope may be evaluated by measuring samples which vary in scattering power and spectral selectivity and comparing these results with those obtained by the standard method.

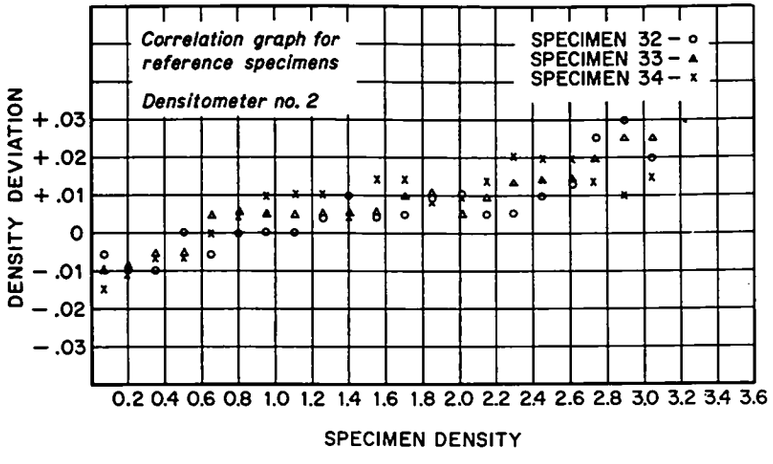
*It is impossible to read thousandths of a density point on all but the most precise instruments. This figure is given as a tolerance based on the statistical average of several readings.





## Appendix

(The Appendix is not a part of this SMPTE Recommended Practice, but is included for information purposes only.)




**American National Standard Diffuse Visual Density Value**
**(from reference specimen calibration chart)**

# SMPTE RECOMMENDED PRACTICE — RP 65-1982

## *Step Optical Reduction Printing of 35-mm Images to 16-mm Prints and Duplicate Negatives*



1. *Scope*

This practice specifies the dimensions of the minimum picture area on 16-mm film made from 35-mm images by step reduction printing.

2. *Objectives*

2.1 This practice specifies the maximum reduction ratio in step optical printing necessary to provide the minimum image area as specified in American National and International Standards.

2.2 The specified dimensions apply to the image area only, taking into account that printer apertures may be reduced to avoid stray light from clear framelines or increased to provide dark surround about prints or certain intermediates.

3. *Dimensions*

3.1 The height and width of the 35-mm negative and positive image are established by American National Standard Dimensions of 35-mm Motion-Picture Camera Aperture Images, ANSI PH22.59-1974 (R1981). The size of the positive image is also controlled by PH22.59 because all the negative area is used when prints are derived as specified by American National Standard Dimensions of Exposed Areas for Picture and Photographic Sound on 35-mm Motion-Picture Prints Made on Continuous Contact Printers, ANSI PH22.111-1982.

3.2 For the production of 16-mm positive prints or intermediates from images with clear (low density) surround, the following dimensions are recommended:

3.2.1 The minimum height of the 35-mm image to be printed shall be 15.95 mm (0.628 in).

3.2.2 The minimum width of the 35-mm image to be printed shall be 21.90 mm (0.862 in).

3.2.3 The size and location of the reduced 16-mm image and surround will be in accordance with American National Standard Location of Printed Areas for 16-mm Picture and Sound Contact Printing, ANSI PH22.48-1976, except that a B minimum value of 7.42 mm (0.292 in) is adopted to conform to the specified minimum image area and to the maximum reduction ratio (see Note 2).

3.2.4 The maximum reduction ratio for step optical printing is 2.15:1.

3.3 For the production of 16-mm duplicate negatives or intermediates from images with dark (high density) surround, the following dimensions are recommended:

3.3.1 The minimum height of the 35-mm image to be printed shall be 16.00 mm (0.630 in).

3.3.2 The minimum width of the 35-mm image to be printed shall be 21.95 mm (0.864 in).

3.3.3 The size and location of the reduced 16-mm duplicate negative image will be in accordance with American National Standard Dimensions of 16-mm Motion-Picture Camera Aperture Image, ANSI PH22.7-1976, except that a B minimum value of 7.42 mm (0.292 in) is adopted to conform to International Standards.

3.3.4 The maximum reduction ratio for step optical printing is 2.15:1.

Notes:

1. Metric dimensions are primary in this recommended practice.

2. When printing reduced 16-mm positive images according to Section 3.2, it is intended that no transparent frameline be produced. The usual practice is to overlap the printed area by increasing the height of the 16-mm printing aperture. It is also acceptable to butt adjoining areas.

When printing reduced 16-mm duplicate negative images according to Section 3.3, it is intended that the frameline be transparent and that the image area printed conform to International Standards. Therefore a 16-mm printing aperture may be used with a height of 7.42 mm (0.292 in) slightly cropping the height of the image projected toward the 16-mm aperture.

3. If means are provided to round the corners of the 16-mm image, the radius of the corner shall not exceed 0.51 mm (0.020 in).

4. The center of the reduced 16-mm image normally shall coincide with the center of the 35-mm image from which it was printed within ± 0.05 mm (0.002 in).



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## Appendix

(The Appendix is not a part of this SMPTE Recommended Practice, but is included for information purposes only.)

In continuous optical reduction printing, the reduction ratio is determined by the ratio of four times the perforation pitch of the 35-mm film source to one times the perforation pitch of the 16-mm print material. The following table compares image dimensions in step optical and continuous optical printing:

| | Minimum 35-mm Image to be Reproduced | | Image Projected toward 16 mm | |
|---|---|---|---|---|
| | Height | Width | Height | Width |
| STEP PRINTER 2.15:1 | | | | |
| Positive | 15.95 mm<br>0.628 in | 21.90 mm<br>0.862 in | 7.42 mm<br>0.292 in | 10.19 mm<br>0.401 in |
| Negative | 16.00 mm<br>0.630 in | 21.95 mm<br>0.864 in | 7.44 mm<br>0.293 in | 10.21 mm<br>0.402 in |
| CONTINUOUS PRINTER 2.49:1 | | | | |
| Positive | 16.00 mm<br>0.630 in | 21.90 mm<br>0.862 in | 6.43 mm<br>0.253 in | 8.80 mm<br>0.346 in |
| Negative | 16.00 mm<br>0.630 in | 21.95 mm<br>0.864 in | 6.43 mm<br>0.253 in | 8.82 mm<br>0.347 in |

Note that in continuous printing, the picture material from Style A or Style B negatives, as specified in ANSI PH22.59-1974, does not fill the normal 16-mm projector aperture as defined in American National Standard Dimensions of Projectable Image Area on 16-mm Motion-Picture Film, ANSI PH22.8-1981. A 35-mm intermediate made from the 35-mm Style A or Style B original with a 16 percent enlargement will produce a 16-mm print at 2.49:1 reduction, which will fill a 16-mm projector aperture satisfactorily. Also note that a 35-mm original with a Style C image area will be satisfactory for direct 2.49:1 reduction.

# SMPTE RECOMMENDED PRACTICE — RP 66-1982

## *Step Optical Enlargement Printing of 35-mm Images from 16-mm Images*



1. *Scope*

This practice specifies the dimensions of the minimum picture area of a 16-mm image used to produce an optically enlarged 35-mm nonanamorphic step printed image.

2. *Objectives*

2.1 This practice specifies the minimum enlargement ratio in step optical printing necessary to provide the minimum 35-mm image area as specified in American National and International Standards.

2.2 The specified dimensions apply to the image area only, taking into account that printer apertures may be reduced to avoid stray light from clear framelines or increased to provide dark surround about prints or certain intermediates.

3. *Dimensions*

3.1 The size and location of the 16-mm camera image is specified in American National Standard Dimensions of 16-mm Motion-Picture Camera Aperture Image, ANSI PH22.7-1976, except that a B minimum value of 7.42 mm (0.292 in) is adopted to conform to International Standards.

3.2 For the production of enlarged 35-mm positive or negative prints or intermediates from images with clear (low density) or dark (high density) surround, the following dimensions are recommended:

3.2.1 The minimum height of the 16-mm camera image to be printed shall be 7.42 mm (0.292 in).

3.2.2 The minimum width of the 16-mm camera image to be printed shall be 10.07 mm (0.396 in).

3.2.3 The size and location of the enlarged 35-mm image will be in accordance with American National Standard Dimensions of 35-mm Motion-Picture Camera Aperture Images, ANSI PH-22.59-1974 (R1981).

3.2.4 The resulting minimum optical enlargement ratio for step optical printing is 2.18:1.

Notes:

1. Metric dimensions are primary in this recommended practice.

2. If means are provided for rounding the corners of the 35-mm image, the radius of the corner shall not exceed 0.8 mm (0.03 in).

3. The center point of the enlarged 16-mm image normally shall coincide with that of the 35-mm printed image within ± 0.05 mm (0.002 in).

### Appendix

(The Appendix is not a part of this SMPTE Recommended Practice, but is included for information purposes only.)

A1. Under the conditions specified for step optical enlargement printing, projection of the enlarged 35-mm image within the dimensions specified in American National Standard Dimensions of Projectable Image Area on 35-mm Motion-Picture Prints, ANSI PH-22.195-1977, will result in an area of the image projected corresponding to that included in an area of 7.01 mm (0.276 in) maximum by 9.61 mm (0.378 in) reference of the original 16-mm frame. Camera users should note the desirability of employing a camera finder matte of these dimensions when exposing 16-mm film which is to be enlarged to 35 mm.

A2. In continuous optical enlargement printing, the enlargement ratio is determined by the ratio of the perforation pitch of the 16-mm film source to four times the perforation pitch of the 35-mm print material. The following table compares image dimensions in step optical and continuous optical printing:



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| | Minimum 16-mm Image to be Reproduced | | Image Projected toward 35 mm | |
|---|---|---|---|---|
| | Height | Width | Height | Width |
| STEP PRINTER 2.18:1 | 7.42 mm<br>0.292 in | 10.07 mm<br>0.396 in | 16.18 mm<br>0.637 in | 21.95 mm<br>0.864 in |
| CONTINUOUS PRINTER 2.50:1 | 7.42 mm<br>0.292 in | 10.07 mm<br>0.396 in | 18.55 mm<br>0.730 in | 25.18 mm<br>0.991 in |

This table does not take into account any cropping or oversize surround printing produced by the 35-mm printing aperture. Note that in continuous printing, the 16-mm camera image will be cropped in the 35-mm projector aperture as defined by ANSI PH22.195-1977.