be drawn to divide the space between each reference into $7^1/_2$ 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.

PROPOSED SMPTE RECOMMENDED PRACTICE RP 15

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 Standard Diffuse Transmission Density, PH2.19-1959, are capable of giving accurate readings of American Standard diffuse transmission density for all types of 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 Standard Diffuse Transmission Density," Type V1-b or Type P2-b, 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 American Standard PH2.19-1959, for either Type V1-b or Type P2-b, and measuring in American Standard diffuse transmission density, shall be used to calibrate the reference specimen.

Note: Calibrated reference specimens are sold by the fabricators of densitometers and sensitometers and by film manufacturers.

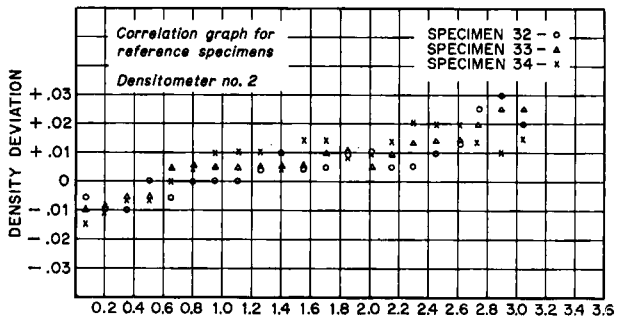
3.3 The reference specimen shall have a range of diffuse transmission densities from below 0.06 to 3.0 or greater.

3.4 The density variation within each step or within each specified calibration area shall be 0.01 or less.

Note: 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.

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 Standard diffuse visual densities Type V1-b or American Standard diffuse printing densities Type P2-b, (American Standard PH2.19-1959). 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.



Appendix: American Standard diffuse visual density value (from reference specimen calibration chart).

* If, during the procedure, deviations in excess of the tolerances shown in 5.2 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.

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.

Note: 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 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 American Standard PH2.19-1959; 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.

Note: 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

Note: 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. A statistical method for controlling this variability is outlined in the SMPTE book, "Control Techniques in Film Processing."

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 non-conforming 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.

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* 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.