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Standard Test Method for Classification of Film Systems for Industrial Radiography[1]

This standard is issued under the fixed designation E 1815; 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.

1. Scope

1.1 This test method covers a procedure for determination of the performance of film systems used for industrial radiography. This test method establishes minimum requirements that correspond to system classes.

1.2 This test method is to be used only for direct exposure-type film exposed with lead intensifying screens. The performance of films exposed with fluorescent (light-emitting) intensifying screens cannot be determined accurately by this test method.

1.3 The values stated in SI units are to be regarded as standard. The values given in bracketsparentheses are for information only.

1.4 *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]

E 94 Guide for Radiographic Examination

E999Guide 999 Guide for Controlling the Quality of Industrial Radiographic Film Processing

E1079Practice 1079 Practice for Calibration of Transmission Densitometers

E 1316 Terminology for Nondestructive Examinations

2.2 *ANSI Standards:*[3]

PH 2.40Root IT2.40 Root Mean Square (rms) Granularity of Film (Images on One Side Only) Method of Measuring

2.3 *ISO Standards:*[3]

ISO 5-2Photography5-2 Photography Density Measurements—Part 2: Geometric Conditions for Transmission Density

ISO 5-3 Photography Density Measurements—Part 3: Spectral Conditions

ISO 7004Photography—Industrial Radiographic Film, Determination of ISO Speed and Average Gradient When Exposed to X and Gamma Radiation Photography—Industrial Radiographic Film, Determination of ISO Speed and Average Gradient When Exposed to X and Gamma Radiation

ISO 11699-1 Non-Destructive Testing—Industrial Radiographic Film—Part 1: Classification of Film Systems for Industrial Radiography

ISO 11699-2 Non-Destructive Testing—Industrial Radiographic Film—Part 2: Control of Film Processing by Means of Reference Values

2.4 *DIN Standard:*[3]

EN 584-1 Non-Destructive Testing—Industrial Radiographic Film—Classification of Film Systems

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology E 1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *film system*—the film and associated film-processing requirements in accordance with the criteria established by the manufacturers of the film and processing chemicals. characteristic curve, *n*—curve showing the relationship between the common logarithm of exposure logK, and the optical density *D*.

3.2.2 *gradient G*—the slope of the characteristic curve at a certain density, *diffuse density*—quantitative measure of film

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[1] This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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

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blackening (optical density) as determined by a densitometer. It is the sum of all transmitted and scattered light into the half sphere behind the film.

3.2.3 *film gradient G*—the slope of the characteristic curve at a specified optical density, *D*, and a measure of the contrast of the film system.

3.2.3*granularity,* σ_D—nonuniformity of density in a radiographic image typically caused by random, statistical groupings of individual silver particles in processed film.

3.2.4 *film system*—the film and associated film-processing requirements in accordance with the criteria established by the manufacturers of the film and processing chemicals.

3.2.5 *film system class*—classification taking into account of limiting values given in Table 1.

3.2.6 *gradient/noise ratio*—ratio of the gradient *G* and the granularity σ_D. It relates directly to the signal/noise ratio. All further parameters determining the signal, such as the modulation transfer function or the energy of the radiation, are considered to be constant.

3.2.6.1 *Discussion*—The limiting values given in this standard are related to fixed radiation energies and specified screens.

3.2.7 *granularity,* σ_D—stochastic fluctuation in a radiographic image, superimposed on the image of the object and typically caused by random, statistical groupings of individual silver particles in processed film.

3.2.8 *ISO speed S*—determined by the dose K_s, measured in gray at a specified optical density, —*reciprocal value of the dose* K_S *measured in Gray, which results in a specified diffuse optical transmission density* *D, in the radiograph.* – $D_0 = 2$ on the processed film, where D_0 is the fog and base density:

$$S = \frac{1}{K_S} \tag{1}$$

3.2.9 *signal/noise ratio*—in industrial radiography the ratio of a local film density to the granularity σ_D at this density level. It is correlated to the gradient/noise ratio.

3.2.10 *specular density*—quantitative measure of film blackening (optical density) when light passing the optics of a microdensitometer transmits the film.

4. Significance and Use

4.1 This test method provides a relative means for classification of film systems used for industrial radiography. The film system consists of the film and associated processing system (the type of processing and processing chemistry). Section 6 9 describes specific parameters used for this test method. In general, the classification for hard X-rays, as described in Section 69, can be transferred to other radiation energies and metallic screen types, as well as screens without films. The usage of film system parameters outside the energy ranges specified may result in changes to a film/system performance classification.

TABLE 3 1 Limiting Values for Gradient, Gradient/Granularity Ratio, and Granularity

ASTM System Class	Minimum Gradient *G* at		Minimum Gradient/ Granularity Ratio, G/σ_D, at $D = 2.0$ above D_o	Maximum Granularity, σ_D, at $D = 2.0$ above D_o
	$D = 2.0$ above D_o [A]	$D = 4.0$ above D_o		
Special	4.5	7.5	300	0.018
I	4.1	6.8	150	0.028
II	3.8	6.4	120	0.032
III	3.5	5.0	100	0.039
W-A	3.8	5.7	135	0.027
W-B	3.5	5.0	110	0.032
W-C	<3.5	<5.0	80	0.039

The classification is only valid for the complete film system. In general, the classification for X-rays as described in 7.1 can be transferred to other radiation energies and metallic screen types as well as films without screens and single coated films.
A certificate shall contain the following information:
–reference to this standard
–date
–measured values of gradient at *A D* = 4 above fog and base
–measured values of gradient at *D D* = 4 above fog and base
–measured granularity at *D* = 2 above fog and base
–calculated value of (D/σ_o = density of an unexposed and processed film including base (fog and base density).
–calculated value of (D/σ_D) at *D* = density of an unexposed and processed film including base (fog and base density).
–Dose K_S for *D* = 2 above fog and base
–Processing conditions:
–Manual or automatic
–Type of chemistry
–Developer immersion time
–Developer temperature
–Classification in accordance with Table 1
Table 2 gives an example for a classification result of different film types, a developer system and given developing conditions.

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~~4.1.1The film performance is described by signal and noise parameters. The signal is represented by gradient and the noise by granularity.~~

~~4.1.2A film is assigned a particular class if it meets all four of the minimum performance parameters: for Gradient *G* at *D*=2.0 and *D*=4.0, granularity σ_D at *D*=2.0, and gradient/noise ratio at *D*~~

4.1.1 The film performance is described by contrast and noise parameters. The contrast is represented by gradient and the noise by granularity.

4.1.2 A film system is assigned a particular class if it meets the minimum performance parameters: for Gradient *G* at $D - D_0 = 2.0$ and $D - D_0 = 4.0$, and gradient/noise ratio at $D - D_0 = 2.0$, and the maximum performance parameter: granularity σ_D at $D = 2.0$, and gradient/noise ratio at $D - D_0 = 2.0$.

4.2 This test method describes how the parameters shall be measured and demonstrates how a classification table can be constructed.

4.3 Manufacturers of industrial radiographic film systems and developer chemistry will be the users of this test method. The result is a classification table as shown by the example given in Table ~~1~~2. ~~This~~Another table also includes speed data for user information. Users of industrial radiographic film systems may also perform the tests and measurements outlined in this test method, provided that the required test equipment is used and the methodology is followed strictly.

4.4 The publication of classes for industrial radiography film systems will enable specifying bodies and contracting parties to agree to particular system classes, which are capable of providing known image qualities. See ~~7.2~~8.

4.5 ISO 11699–1 and European standard ~~EN584-1~~EN 584-1 ~~describes a similar~~describe the same method for classification of film systems for industrial radiography, but its class definitions and number of classes do not align exactly with this test method. International users of these standards should be aware of these differences for their particular applications.

NOTE 1—ASTM research report E07–1005 contains documentation of technical methods used during the development of this test method.[4]

5. ~~Sampling and Storage~~

~~5.1For determination of the gradient and granularity of a film system, it is important that the samples evaluated yield the average results obtained by users. This will require evaluating several different batches periodically, under the conditions specified in this test method. Prior to evaluation, the samples shall be stored in accordance with the manufacturer's recommendations for a length of time to simulate the average age at which the product is normally used. Several independent evaluations shall be made to ensure the proper calibration of equipment and processes. The basic objective in selecting and storing samples as described above is to ensure that the film characteristics are representative of those obtained by a consumer at the time of use.~~

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~~6.Procedure~~

~~6.1*Principle*:~~

~~6.1.1Film to be tested shall be exposed to X-rays from tungsten target tubes. Inherent filtration of the tube, plus an additional copper filter located as close to the target as possible, shall provide filtration equivalent to 8.00 ± 0.2 mm of copper.~~

~~6.1.2The film system includes a front and a back screen of 0.02 to 0.25-mm lead. If single-coated films are used, the emulsion-coated surface must face the X-ray tube. Vacuum or pressure cassettes may be used to ensure sufficient contact between the film and screen.~~

~~6.2*X-ray Spectral Quality*:~~

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: E07–1005.

TABLE ~~1~~ 2 Typical Film System Classification

Automatic Film Processing
Developer: Type A
Developer immersion time: XXX seconds
Developer temperature: XX°C/YY°F

Film Type[A]	ASTM System Class	Minimum Gradient *G* at		Minimum Gradient/ Granularity Ratio, G/σ_D, at $D = 2.0$ above D_o	Maximum Granularity, σ_D, at $D = 2.0$ above D_o	ISO Speed S	Dose, K_s, *m* Gy, $D = 2.0$
		$D = 2.0$ above D_o	$D = 4.0$ above D_o				
A	Special	5.4	9.1	360	0.015	32	29.0
B	I	4.5	8.4	281	0.016	64	14.0
C	I	4.4	7.6	232	0.019	100	8.7
D	I	4.4	7.6	169	0.026	200	4.6
E	II	4.4	7.6	142	0.031	320	3.2
F	III	4.0	5.2	114	0.035	400	2.5
G	W-A	4.2	6.5	225	0.019	100	8.6
H	W-B	4.1	5.3	170	0.025	300	5.0

[A] Family of films ranging in speed and image quality.

6.2.1Use the same X-ray spectral quality for determining both the film gradient and its root mean square granularity. Make the film exposures with an 8-mm [0.32-in.] copper filter at the X-ray tube and the kilovoltage set such that the half-value layer in copper is 3.5 mm [0.14 in.]. The kilovoltage setting will be approximately 220 kV.

6.2.2Determine the required kilovoltage setting by making an exposure (or exposure rate) measurement with the detector placed at a distance of at least 750 mm [29.5 in.] from the tube target and with an 8-mm [0.32-in.] copper filter at the tube. Then make a second measurement with a total of 11.5 mm [0.45 in.] of copper at the tube. These filters should be made of 99.9% pure copper.

6.2.3Calculate the ratio of the first and second readings. If this ratio is not 2, adjust the kilovoltage up or down and repeat the measurements until a ratio of 2 (within 5%) is obtained. Record the machine setting of the kilovoltage for use with the film tests.

6.3*Film Cassette and Screens*:

6.3.1The film cassette (holder) shall provide a means of ensuring good film screen contact. A vacuum cassette may be used.

6.3.2Lead-foil screens shall be used with the front-screen thickness being 0.130 ± 0.013 mm [0.005 ± 0.05 in.] and the back-screen thickness being 0.250 ± 0.025 mm [0.010 ± 0.001 in.].

NOTE2—These thicknesses reflect commercially available tolerances in lead foil for use as radiographic screens.

6.3.3It is especially important that the exposure to the film specimen for the granularity measurements be spatially uniform. Any nonuniformities in X-ray transmission of the cassette front or nonuniformities or defects in the lead-foil screens could influence the granularity measurement. Therefore, exercise considerable care in selection and maintenance of the cassette and lead screens to minimize these effects.

6.3.4Expose single-coated films with the emulsion-coated surface in contact with the front screen.

6.4*Film Processing*—The film image quality will vary with the processing variables, such as chemistry, temperature, and method of processing (manual or automatic). The film processing and record requirements shall be in accordance with Guide E999Microdensitometer Requirements

5.1 The influx aperture of the microdensitometer shall be approximately circular in shape, with a diameter (referred to the plane of the specimen) not less than 1.2× or more than 2× the diameter of the efflux aperture.

5.2 The reduction of the influx aperture by the influx optics and the magnification of the specimen onto the efflux aperture by the efflux optics shall lie in the range from 20 to 100×. The two magnifications need not be equal.

5.3 The efflux (or measuring aperture) shall be preferably circular in shape. Its effective diameter referred to the specimen plane shall be 100 ± 5 µm.

5.4 The spectral response of the microdensitometer system shall be visual, as specified by ISO 5-3.

6.5*Exposure Conditions*:

6.5.1The plane of the film shall be normal to the central ray of the X-ray beam. Use a diaphragm at the tube to limit the field of radiation to the film area. The X-ray tube target to film distance shall be adequate to ensure that the exposure over the useful area of each exposure step is uniform to within 3%.

6.5.2To minimize the effects of backscattered radiation, use a 6.3 ± 0.8-mm [¼ ± 1⁄32-in.] thick lead shielding behind the cassette. The shielding lead shall extend at least 25 mm [1 in.] beyond each edge of the cassette. Alternatively, the shielding lead may be omitted, provided that the cassette is supported such that the X-ray beam strikes no scattering material, other than air, for a distance of at least 2 m [78.7 in.] behind the cassette.

6.5.3Modulation of the X-ray exposure may be accomplished by changing the exposure time or tube target to film distance. Changing the tube current is not recommended but may be done, provided it is verified by measurement (see 6.2) that the X-ray spectral quality does not change.

6.5.4Measure exposures with an air-ionization chamber, or other types of X-ray detectors, having linear response over the range of X-ray intensities and exposure times used for the film exposures.

6.5.5During and after exposure, prior to processing, keep the film at a temperature of 23 ± 5°C [59.7 ± 5°F] and a relative humidity of 50 ± 20%. Start processing of the film between 30 min and 8 h after exposure. Process an unexposed specimen of the film sample with the X-ray-exposed specimen in order to determine the base plus fog density.

6.5.6Measure the visual diffuse transmission density of the processed films with a densitometer complying with the requirements of ISO 5-2 and calibrated by the method of Practice E1079. Use a minimum aperture of 7 mm [0.275 in.].

6.6

5.5 An electronic band-pass filter, used to reduce the unwanted signal caused by system artifacts, shall have its low-frequency boundary set so the system response is 3 dB down at a temporal frequency corresponding to a spatial frequency of 0.1 cycles/mm. Its high-frequency boundary shall be set so that the system response is 3 dB down at a temporal frequency corresponding to the first zero in the spatial frequency response of the circular aperture. Mathematical procedures that can be shown to produce equivalent reductions in the effects of system artifacts are acceptable alternatives to the use of this filter (see 7.3).

6. Sampling and Storage

6.1 For product specification it is important that the samples evaluated yield the average results obtained by users. This will require the evaluation of several different batches periodically under conditions specified in this standard. Prior to evaluation, the samples shall be stored according to the manufacturers' recommendations for a length of time to simulate the average age at which the product is normally used. The basic objective in selecting and storing samples as described above is to ensure the film

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characteristics are representative of those obtained by a consumer at the time of use.

7. Test Method

7.1 *Preparation*

7.1.1 The film samples shall be exposed to X-rays from tungsten target tubes. Inherent filtration of the tube, plus an additional copper filter located as close to the X-ray tube target as possible shall provide filtration equivalent to (8.00 ± 0.05) mm of copper. The potential across the X-ray tube shall be adjusted until the half-value-absorption is obtained with (3.5 ± 0.2) mm of copper. A potential of approximately 220 kV generally meets this requirement.

7.1.2 The film system shall include a front and a back screen of 0.02 to 0.04 mm lead. If single coated films are used, the emulsion coated surface shall face the X-ray tube. Good film screen contact shall be ensured.

7.1.3 Exercise care to ensure that the film specimen does not contain density variations arising from the exposing equipment (such as non-uniform beam filters or damaged, or defective lead screens) or processing system. During and after exposure, prior to processing, maintain the film specimen at the temperature of 23°C ± 5°C and relative humidity of 50 ± 20 %. The film processing chemicals and procedures shall be the same for determining gradient and granularity, and they shall be used and described completely as specified.

7.1.4 Use manufacturer certified film test strips in accordance with ISO 11699-2 to test the specified developer system with the specified immersion time and developer temperature. The speed index S_x shall be within ±5 % of the manufacturer's certificate. The developer temperature may differ by ±1°C from the certified value to adjust S_X within ±5 % of the manufacturer certificate value. The obtained S_X and used developer temperature shall be documented in the test report. This test shall be done, on a daily basis, before and after the development of the exposed films for classification with the same developer temperature and immersion time.

7.1.5 If a manufacturer certificate is not available, film test strips shall be manufactured and calibrated according to ISO 11699-2 by the user.

7.2 *Measurement of Gradient G*:

7.2.1 Gradient *G* relates to a *D* versus log *versus* $\log_{10}$*K curve. In the scope of this test method, G is calculated from the slope* dD/dK *of a D versus K curve at density (* $D - D_o$*), as follows:*

$$G = \frac{dD}{d\log K} = \frac{K}{\log e} \times \frac{dD}{dK} \quad (2)$$

$$G = \frac{dD}{d\log_{10} K} = \frac{K}{\log_{10} e} \times \frac{dD}{dK} \quad (2)$$

where:

K = dose required for density $D - D_o$, and

D_o = fog and base density.

6.6.2The

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7.2.2 The *D* versus *K* curve is approximated by a polynomial of third order. To obtain a reliable curve, a series of exposures are made with the same film sample to obtain at least twelve uniformly distributed measuring points covering at least density 1,0 and 4,5 above D_0. The polynomial approximation shall include all measured values between 1,0 and 4,5. For the numerical approximation (fit procedure) no zero value shall be included. At least six gradient measurements shall be made on different film samples to determine the mean gradient value G. The densitometer used shall be calibrated regularly up to a diffuse density of $D \geq 4.8$. For the calibration, a certified film step tablet shall be used. This shall be generated from double sided X-ray film of System Class 1 or special.

The *D* versus *K* curve is approximated by a polynomial of the third order. To obtain a regular and reliable shape of this curve, make a series of exposures to obtain at least 12twelve uniformly distributed measuring points between density 1.0 and 5.0 above D_{o0}.

6.6.3Average the Gradient *G* measurements, with a maximum inaccuracy of ±5%.

6.7*Root Mean Square (rms) Granularity,* σ_D:

6.7.1Determine the rms granularity of the film in accordance with ANSI PH 2.40, with the following exceptions:

6.7.2The procedure is limited to the measurement of continuous tone black-and-white industrial X-ray films viewed by transmitted light. The film may have emulsion coated on one side or both sides of the film support.

6.7.3Expose the film specimen with X-rays having the spectral quality described in 6.2. The cassette and lead-foil screens shall be as specified in 6.3. Expose the film specimen in accordance with the exposure conditions of 6.5. Exercise care to ensure that the film specimen does not contain density variations arising from the exposing equipment (such as nonuniform beam filters or damaged or defective lead screens). During and after exposure, prior to processing, maintain the film specimen at the temperature and relative humidity conditions specified in 6.5.5. The film processing chemicals and procedures shall be the same as those used for determining gradient, and they shall be described completely as specified in 6.4

NOTE 2—Densitometers may have limited accuracy for measurements at $D > 4$ and need careful calibration correction in the full range. Small deviations of the density values at $D > 4$ have considerable influence to the accuracy of the *G* at $D - D_0 = 4$ – value due to the properties of the polynomial approximation procedure.

7.2.3 The mean gradient values shall be determined with a maximum uncertainty of ±5 % for the gradient at $D = 2$ above fog and base (G2) at a confidence level of 95 % and ±7 % for the gradient at $D = 4$ above fog and base (G4) at a confidence level of 95 %.

7.2.4 Measurement laboratories, which certify film systems, shall participate in a proficiency test on a periodical basis. A new film, exposed in accordance with this standard, shall be used in all participating laboratories and for each periodical test.

7.3 *Measurement of Granularity* σD

7.3.1 The granularity is measured by linear or circular scanning of a film of constant diffuse optical density with a microdensitometer. Both emulsion layers shall be recorded; this means that the depth of focus of the microdensitometer has to include both layers.

7.3.2 The granularity value shall be determined in terms of diffuse density.

7.3.3 If the optical density is measured as specular density, it shall be converted into diffuse optical density, using the plot of the curve of diffuse density versus specular density at the mean density value of the granularity film specimen. The diffuse density of each step shall be measured with the calibrated densitometer.

7.3.4 Determine this curve using a film having a stepped series of densities, which is prepared using the same type of film, exposure, and processing techniques as used for the granularity film specimen. The specimen film shall be scanned using identical microdensitometer settings. A limited range of densities can typically be measured for a given microdensitometer gain setting.

7.3.5 The stepped series of densities shall lie within that range.

7.3.6 The calibration shall be made from the diffuse vs specular density plot with at least five values between diffuse density 1.5 and 2.8 (including fog and base). The conversion can be performed on basis of a linear regression analysis of the log (diffuse density) vs. log(specular density) plot. The determined coefficients shall be used for the conversion of the specular density into diffuse density values.

7.3.7 The conversion shall be performed before the numerical determination of the standard deviation σ_D, which is a measure of the granularity. σ_D is calculated by:

$$\sigma_D = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^{N} (D_i - \overline{D})^2} \quad (3)$$

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7.3.8 The diffuse optical density of the measured film shall be above fog and base. The determined σ_D value shall be corrected on the basis of the diffuse mean density above fog and base of this film. The corrected σ_D-value is calculated by:

$$\sigma_{D-corr} = \sigma_D \cdot \sqrt{2/\overline{D}} \quad (4)$$

7.3.9 As an alternative, three or more samples of the film specimen at different density levels, within the range from 1.80 to 2.20, may be measured, and the granularity value at a diffuse density of 2.00, above base plus fog, shall be taken from a linear regression analysis of the plot of granularity as a function of the square root of diffuse density above fog and base.

7.3.10 The scanning length on the radiographic film shall be at least 116 mm. The diameter of a circular measuring aperture of the microdensitometer shall be (100 ± 5) µm. A square aperture of 88.6 µm by 88.6 µm has the same area as a circular one of 100 µm diameter and is concerning the measured granularity equivalent to a circular one with 100 µm diameter.

7.3.11 The determined $\sigma_{D\text{-}corr\text{-}value}$ shall be corrected on the basis of the real (measured) aperture diameter A_d(in µm) of a circular aperture. The corrected σ_D-value is calculated by:

$$\sigma_{D-corr}\text{–}a = \sigma_{D-corr} \cdot (A_d/100) \quad (5)$$

7.3.12 If a square aperture of the microdensitometer is used, the corrected σ_D-value is calculated by:

$$\sigma_{D-corr}\text{–}b = \sigma_{D-corr} \cdot \sqrt{(4 \cdot A_d/(\pi \cdot 10000))} \quad (6)$$

where A_a is the aperture area in µm ^{2}.

~~6.7.4The film specimen for granularity measurement shall have a diffuse density of 2.00 ± 0.05 above base plus fog. As an alternative, three or more samples of the film specimen at different density levels, within the range from 1.80 to 2.20, may be measured, and the granularity value at a diffuse density of 2.00, above base plus fog, shall be taken from a smooth curve drawn through a plot of the data points. The granularity value shall be in terms of diffuse density.~~

~~6.7.4.1The microdensitometer scanner output is measured as projection density. Thus to obtain the desired diffuse density, convert the data using the slope of the curve of diffuse density versus projection density at the mean density value of the granularity film specimen. Determine this curve using a film having a stepped series of densities, which is prepared using the same type film, exposure, and processing techniques as used for the granularity film specimen. Measure the diffuse density of each step with a microdensitometer. The specimen film shall be scanned using identical microdensitometer settings. A limited range of densities can typically be measured for a given microdensitometer gain setting. The stepped series of densities shall lie within that range. Choose the number of steps such that the slope of the curve, at the mean density of the granularity film specimen, is determined to an accuracy of ±5%.~~

~~6.7.5Determine the granularity of the film specimen by evaluating no fewer than three samples of the specimen and determining their mean so that a maximal uncertainty of 10% is achieved.~~

~~6.7.6Adjust the optical system of the microdensitometer so that both emulsions, or the one emulsion in the case of a~~