Designation: E 1735 – 95 (Reapproved 2000)ε1

Standard Test Method for Determining Relative Image Quality of Industrial Radiographic Film Exposed to X-Radiation from 4 to 25 MV[1]

This standard is issued under the fixed designation E 1735; 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.

ε[1] NOTE—Paragraph 8.5 was corrected editorially in May 2000.

1. Scope

1.1 This test method covers determination of the relative image quality response of industrial radiographic film when exposed to X-radiation sources having photon energies from 4 to 25 MV. Evaluation of the film is based on the visibility of holes in a special image quality indicator (IQI). Since results for a given film type may vary, depending on the particular processing system used, it is essential to state the exposure parameters, processing chemistry, and processing cycle. For the purposes of this test method, it is assumed that all components of the X-ray system are operating properly and are capable of producing a given image quality. This test method is not intended to be used for films exposed with Cobalt 60 sources or X-ray sources below 4 MV.

1.2 The values stated in either SI or inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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:*

E 999 Guide for Controlling the Quality of Industrial Radiographic Film Processing[2]

E 1025 Practice for Hole Type Image Quality Indicators Used for Radiography[2]

E 1079 Practice for the Calibration of Transmission Densitometers[2]

E 1316 Terminology for Nondestructive Examinations[2]

3. Terminology

3.1 *Definitions*—Definitions of terms relating to gamma and X-radiology are found in Terminology E 1316.

4. Significance and Use

4.1 This test method provides a test for determining the relative image quality response of radiographic film when exposed to 4 to 25 MV X rays as any single component of the total X-ray system (for example, screens) is varied. By holding the technique parameters (except exposure time) and processing parameters constant, the image quality response of radiographic film may be evaluated on a relative basis.

4.2 Alternately, this test method provides a test for measuring the image quality of the X-ray system or any component of the system.

5. Test Specimen

5.1 The test specimen will consist of a 15-cm (6-in.) steel absorber with a special IQI placed on the radiation (source) side of the absorber.

5.1.1 *Absorber*—The absorber shall be made of carbon steel or Type 300 stainless steel. The thickness of 15 cm (6 in.) can be achieved by stacking thinner plates whose length and width shall be at least 20 by 25 cm (8 by 10 in.). The surface finish of the top and bottom of the absorber shall be a maximum of 6.3-µm (250-µin.) R_a ground finish.

5.1.2 *Image Quality Indicator*—The IQI shall be fabricated of carbon steel or Type 300 stainless steel and shall conform to Fig. 1. The IQI steps, identified as Plaques A-D, may be fabricated separately and then taped together, as shown in Fig. 1, using suitable tape to form the array as shown. The tape shall not cover any of the holes in the IQI. The surface finish of the IQI top and bottom surfaces shall be a maximum of 6.3-µm (250-µin.) R_a ground finish.

6. Radiation Source

6.1 The source of radiation shall be an X-ray generator capable of operating in any part (or all) of the range from 4 to 25 MV.

7. Film Holder and Screens

7.1 *Film Holder*—The film holder shall be a medical-type, hard-backed cassette or a flexible film holder with a vacuum or mechanical means for providing good film-screen contact.

[1] This test method is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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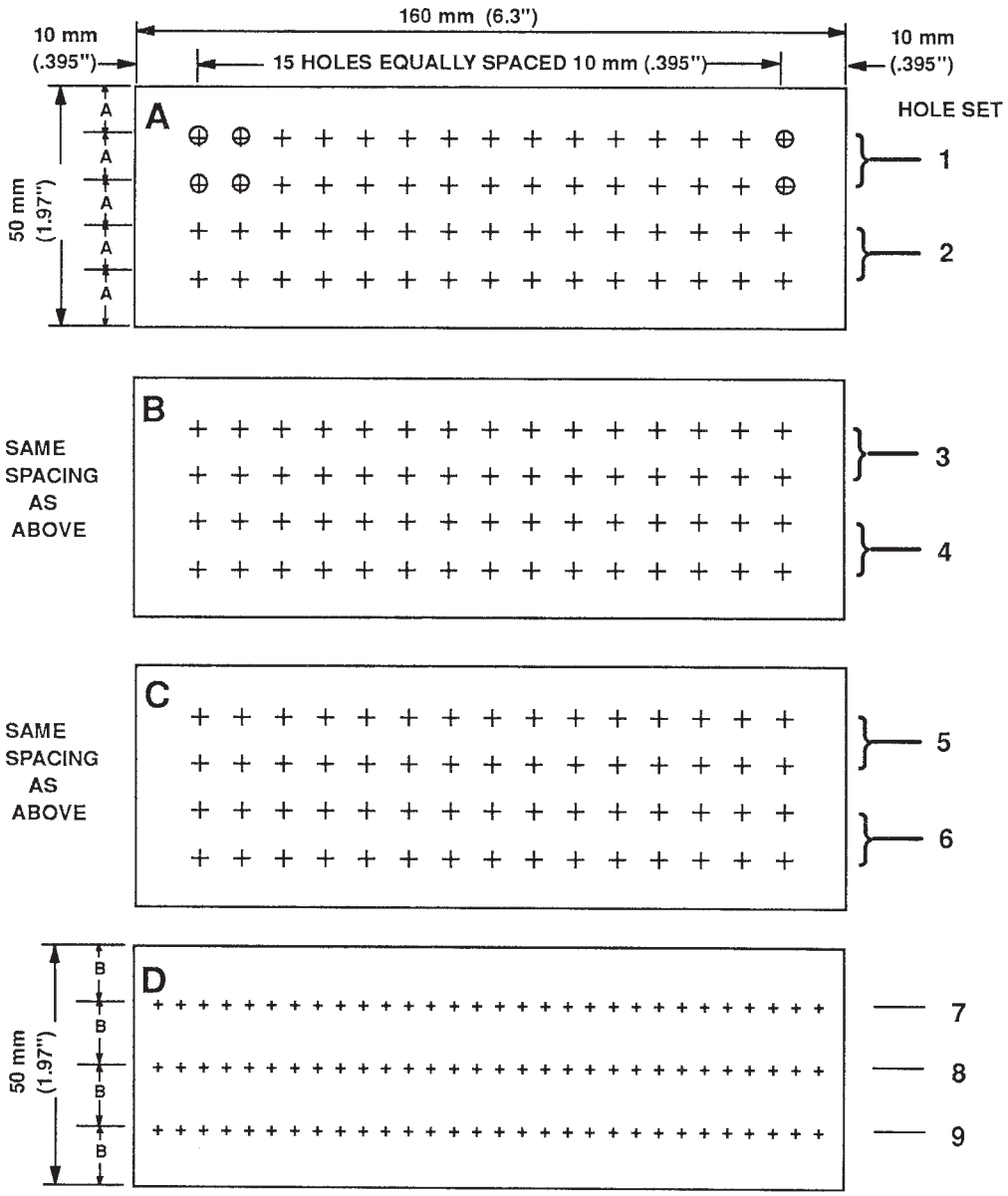
[2] *Annual Book of ASTM Standards*, Vol 03.03.



NOTE 1—All plaques identical except hole size and plaque thickness hole: row spacing tolerance ± 0.1 mm (± 0.004 in.), nonaccumulative Dimension A = 10 ± 0.1 mm (0.395 ± 0.004 in.) and Dimension B = 12.5 ± 0.1 mm (0.492 ± 0.004 in.); other dimensions in accordance with standard engineering practice.

Plaque Letter	Plaque Thickness		Hole Set	Hole Diameter	
	mm	(in.)		mm	(in.)
A	1.6 ± 0.025	(0.0625± 0.001)	1	3.0 ± 0.025	(0.118 ± 0.001)
B	1.3 ± 0.025	(0.050 ± 0.001)	2	1.8 ± 0.025	(0.072 ± 0.001)
C	0.97 ± 0.025	(0.038 ± 0.001)	3	1.8 ± 0.025	(0.072 ± 0.001)
D	0.64 ± 0.025	(0.025 ± 0.001)	4	1.5 ± 0.025	(0.060 ± 0.001)
			5	1.5 ± 0.025	(0.060 ± 0.001)
			6	1.22 ± 0.025	(0.048 ± 0.001)
			7	1.42 ± 0.025	(0.056 ± 0.001)
			8	1.17 ± 0.025	(0.046 ± 0.001)
			9	0.94 ± 0.025	(0.037 ± 0.001)

FIG. 1 Image Quality Indicator

7.2 *Screens*—Lead foil screens with a front thickness of 0.010 to 0.050 in. (0.25 mm to 1.27 mm) and back thickness of 0.010 in., minimum, shall be used. Thicker screens may be used at the user's discretion, provided that the actual thickness used is documented on the data sheet (Fig. 2) and agreed upon by all parties concerned.

ORGANIZATION _____ DATE _____

FILM AND EXPOSURE DATA

FILM TYPE _____ READER _____

MEGAVOLTAGE _____ X-RAY SOURCE _____

SOURCE TO FILM DISTANCE _____ FOCAL SPOT SIZE _____ mA-S/RADS _____

SCREENS (MATERIAL) _____ THICKNESS: FRONT _____ BACK _____

PROCESSING

AUTOMATIC	MANUAL	DRY
BRAND NAME _____	DEVELOPER	PROCESSOR
TYPE _____	BRAND TYPE _____	BRAND TYPE _____
TEMP. _____	TEMP. _____	TEMP. _____
TIME _____	TIME _____	TIME _____
REPLENISHMENT		
RATE _____	SEASONING, auto. _____	manual _____ dry _____

INTERPRETATION

I.Q.I. PLAQUE THICKNESS (T)		HOLE DIA.(D)		INDEX (T)x(D)		NUMBER OF VISIBLE HOLES			
mm.	(in.)	mm.	(in.)	mm^2	($in.^2$)	Expos.	Expos.	Expos.	AVG.
1.6	(.063)	3.0	(.118)	4.80	(.0074)	_____	_____	_____	_____
		1.8	(.072)	2.88	(.0045)	_____	_____	_____	_____
1.3	(.050)	1.8	(.072)	2.34	(.0036)	_____	_____	_____	_____
		1.5	(.060)	1.95	(.0030)	_____	_____	_____	_____
0.97	(.038)	1.5	(.060)	1.43	(.0023)	_____	_____	_____	_____
		1.22	(.048)	1.16	(.0018)	_____	_____	_____	_____
0.64	(.025)	1.42	(.056)	0.91	(.0016)	_____	_____	_____	_____
		1.17	(.046)	0.75	(.0012)	_____	_____	_____	_____
		0.94	(.037)	0.60	(.0009)	_____	_____	_____	_____

FIG. 2 Data Sheet for Evaluating the Image Quality Response of Radiographic Film (4 to 25 MV)

8. Test Procedure

8.1 *Source to Film Distance*—The source to film distance is based on achieving a geometrical unsharpness (U_g) of 0.15 mm (0.006 in.) or less when used with the test specimens described in Section 5. The minimum source to film distance to be used shall be 1 m (39.4 in.).

8.2 *Film/Test Specimen: Source Relationship and Film Placement*—The plane of the film and test specimen shall be normal to the central ray of the radiation source. Collimate the source so as to limit the radiation source to the film. Place the film holder/cassette opposite the source side and in contact with the absorber.

8.3 *Film Identification*—Identify the film number and source energy used by means of lead numbers and letters placed on the corner of the plate so as not to interfere with the images of the holes in the IQI. Note that the letters and numbers will be magnified when placed on the source side of the absorber.

8.4 *Exposure*—Adjust the exposure time to provide a film density of 2.00 ± 0.1 in the center of the film, as measured with a densitometer calibrated in accordance with Practice E 1079. Make three exposures using the same film holder/cassette in accordance with 7.1.

8.5 *Film Processing*—In order to minimize any effects caused by the latent image instability, process the exposed film not more than 4 hours after exposure. Either manual or automatic processing may be used, in accordance with Guide E 999 and as follows:

8.5.1 *Automatic Processing*—Use industrial X-ray film automatic processing solutions. Maintain a record on the data sheet of the following:

8.5.1.1 The brand name and type of processor;

8.5.1.2 The length of time (±1 s) that the film is in the developer, that is, leading edge in to leading edge out;

TABLE 1 Average Number of Visible Holes

Film Type	1	2	3	4	5	6	7	8	Visibility Index
I	30	30	30	23	12.7	0	0	0	125.7
II	30	27.7	25.2	12.2	0	0	0	0	95.1
III	30	26.5	21.7	8.7	0	0	0	0	86.9
IV	30	25.2	15.7	5.3	1	0	0	0	77.2

8.5.1.3 The brand name of the processing chemicals, including the starter, processing temperature to within 0.5°C, and replenishment rate; and

8.5.1.4 The total quantity of film used in seasoning fresh developer solutions. With fresh developer solutions, process a minimum of ten films (360 by 430 mm (14 by 17 in.))/gal of developer. Each film should be half-flashed[3] to a density of 4.0 or greater using white light or, alternatively, fully flash alternate sheets.

8.5.2 *Manual Processing*—Use industrial X-ray film processing solutions in the tests. Maintain a record on the data sheet of the following:

8.5.2.1 The time of development (± 2 s);

8.5.2.2 The temperature of the developer within 0.5°C;

8.5.2.3 The total quantity of films used in seasoning fresh developer solutions. With fresh developer solutions, process a minimum of ten films (360 by 430 mm (14 by 17 in.))/gal of developer. Each film should be half-flashed[3] to a density of 4.0 or greater using white light or, alternatively, fully flash alternate sheets;

8.5.2.4 The replenishment system used; and

8.5.2.5 The brand name of the processing chemicals.

8.5.3 *Dry Processing*—Use the manufacturer's recommended processing procedures. Maintain a record on the data sheet of the following:

8.5.3.1 The brand name of the processor; and

8.5.3.2 The length of time that the film is in the processor, that is, leading edge in to leading edge out.

9. Data Collection and Evaluation

9.1 The three test films for any one film type should be read independently by three readers. Each reader shall record the number of holes of a given size visible at each step of the IQI. A magnifier up to 3× is permitted for viewing the film. A sample data sheet is shown in Fig. 2.

9.2 The data are evaluated by averaging the number of holes of a given size (hole set) visible on each plaque image of the IQI for each film type. This average is based on the evaluation of three readers of three radiographs for each film type. This averaging procedure is repeated for each film type and is a measure of the relative image quality response of a given film type.

9.2.1 The relative image quality response for different film types is illustrated in Table 1.

9.3 *First Alternate (Optional) Method of Evaluation*—Each hole set is converted to equivalent image quality sensitivity (EIQS), as prescribed in the Appendix of Practice E 1025. Plot the number of visible holes after averaging versus the EIQS values for each hole set. This gives a set of points on a graph through which a continuous smooth curve is drawn. The image quality response is determined at the point where 50 % of the holes are visible. This value is the classification index for the film under testing. Fig. 3 is an idealized illustration of this curve plotting method.

9.4 *Second Alternate (Optional) Method of Evaluation*:

9.4.1 In addition to the two methods previously described, the classification index may be calculated mathematically between two adjacent hole sets by interpolating between the EIQS values of the hole set with more than 15 visible holes and the set with less than 15 visible holes by use of the following formula:

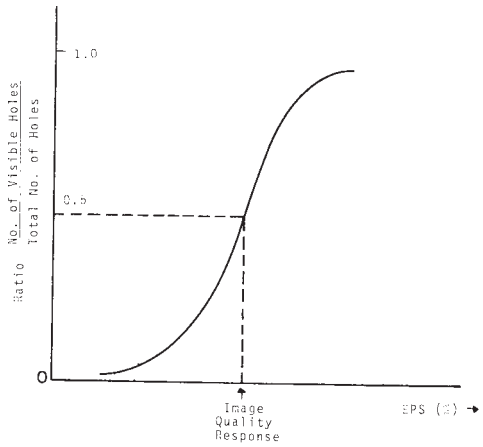


FIG. 3 Visibility Versus EPS Values

[3] Half-flashed implies that one half the total film area of each film is exposed to the white light source prior to development.

$$C = Q_b + \frac{(15 - N_b)(Q_a - Q_b)}{N_a - N_b} \quad (1)$$

where:

C = classification index (the midpoint or 50 % point on the graph in 9.3),

N_a = total number of visible holes in the hole set immediately above the midpoint, and Q_a = corresponding EIQS value, and

N_b = total number of visible holes in the hole set immediately below the midpoint, and Q_b = corresponding EIQS value.

9.4.2 The following example is given for illustration. A set having 23 visible holes has an EIQS value of 1.57. An adjacent set has 12 visible holes and an EIQS value of 1.49. Inserting these values into the formula yields the following:

$$C = 1.49 + \frac{(15 - 12)\,(1.57 - 1.49)}{23 - 12} \quad (2)$$

$$C = 1.51$$

10. Precision and Bias

10.1 No statement is made about the precision and bias for indicating the quality of radiographs since the results state merely whether there is conformance to the criteria for success specified in this test method.

11. Keywords

11.1 EIQs; film; IQI; radiation; radiographic; X-ray