Designation: E 746 – 93 (Reapproved 1998)

An American National Standard

Standard Test Method for Determining Relative Image Quality Response of Industrial Radiographic Film[1]

This standard is issued under the fixed designation E 746; 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 the determination of the relative image quality response of industrial radiographic film when exposed to 200-kV X rays. The evaluation of the film is based upon the threshold visibility of penetrameter holes in a special image quality indicator (IQI). Results for a given film type may vary, depending upon the particular development system used. It is, therefore, necessary to state the development system and geometric conditions used in this determination. 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.

1.2 Alternately this test method may be used for determination of the relative image quality response of a radiographic film when exposed to 200-KV X-rays as any other single component of the system (such as screens) is varied.

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:*

B 152 Specification for Copper Sheet, Strip, Plate, and Rolled Bar[2]

2.2 *ANSI Standard:*

ANSI PH2.8 Sensitometry of Industrial X-ray Films for Energies up to 3 Million Electron Volts[3]

3. Test Specimen

3.1 The test specimen shall consist of a special image quality indicator (IQI) placed on the tube side of a 19-mm (¾-in.) steel plate.

3.1.1 The special image quality indicator (IQI) shall be fabricated from mild steel. The dimensions shall conform to Fig. 1. The IQI steps may be fabricated separately and taped together to form the penetrameter array as shown. The tape shall not cover any of the holes in the IQI.

3.1.2 The absorber plate shall be made of mild steel. It shall be at least 200 by 250 mm (8 by 10 in.) and 19 ± 0.12 mm (0.750± 0.005 in.) thick. The surface finish of the absorber plate shall be a maximum of 6.3 µm (250 µin.) R_a, ground finish (both faces).

4. Calibration of X-Ray Source

4.1 The voltage calibration of the X-ray source is based on ANSI PH2.8. With an 8-mm (0.32-in.) copper filter at the X-ray tube and a target to detector distance of at least 750 mm (29.5 in.), adjust the kilovoltage until the half value layer in copper is 3.5 mm (0.14 in.) (see Specification B 152). Make a reading of the detector with 8 mm of copper at the tube, and then make a second reading with a total of 11.5 mm (0.45 in.) at the tube.

4.2 Calculate the ratio of the two readings. If this ratio is not 2, adjust the kilovoltage up or down and repeat the measurement until a ratio of 2 (within 5 %) is obtained. Record the machine settings and use for the film tests. During tests, remove the 8 mm (0.32 in.) and 3.5 mm (0.14 in.) of copper.

5. Film Holder and Screens

5.1 Enclose a single film in a cassette with low absorption. *The cassette shall provide a means for ensuring good film-screen contact.*

5.2 Place the film between lead-foil screens, the front screen being 0.130 ± 0.013 mm (0.005 ± 0.0005 in.) thick and the back screen 0.250 ± 0.025 mm (0.010 ± 0.001 in.) thick.

NOTE 1—These thicknesses reflect commercially available tolerances in lead foil for use as radiographic screens.

5.3 When the component to be evaluated is a screen or screen system, other than lead screen as specified in 5.2, place the film in the proper position with the screen or screen system.

5.4 Use a 6.3 ± 0.8 mm (¼ ± 1⁄32 in.) thick lead "backup" behind the cassette. The backup lead shall extend at least 25 mm (1 in.) beyond each edge of the cassette.

6. Procedure

6.1 The sources to film distance is based upon achieving a geometrical unsharpness (Ug) of 0.05 mm (0.002 in.) or less on

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[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 Radiographic Practice and Penetrameters.

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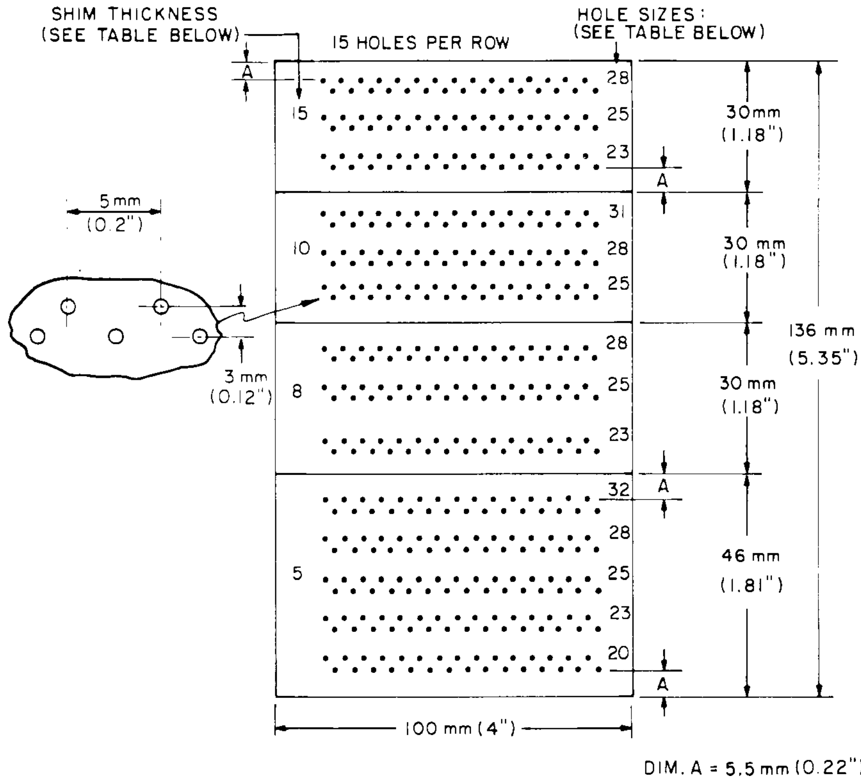
[2] *Annual Book of ASTM Standards*, Vol 02.01.

[3] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.



Step Identification	Shim Thickness, mm (in.)	Hole Identification	Hole Size, mm (in.)
15	0.38 ± 0.012 (0.015 ± 0.0005)	32	0.81 ± 0.025 (0.032± 0.001)
10	0.25 ± 0.012 (0.010 ± 0.0005)	31	0.79 ± 0.025 (0.031 ± 0.001)
8	0.20 ± 0.012 (0.008 ± 0.0005)	28	0.71 ± 0.025 (0.028± 0.001)
5	0.13 ± 0.012 (0.005 ± 0.0005)	25	0.64 ± 0.025 (0.025 ± 0.001)
		23	0.58 ± 0.025 (0.023± 0.001)
		20	0.50 ± 0.025 (0.020 ± 0.001)

Hole Spacing (horizontal): 5 ± 0.1 mm (0.2 ± 0.004 in.) Nonaccumulative
Row Spacing: 3 ± 0.1 mm (0.2 ± 0.004 in.)
Spacing between hole sets: 5 ± 0.1 mm (0.2 ± 0.004 in.)
All other dimensions shall be in accordance with standard engineering practice.

FIG. 1 Image Quality Indicator

a 19-mm (¾-in.) thick absorber plate. Calculate the minimum source to film distance, *D*, in millimetres, as follows:

$$D = 381\,\phi$$

where:
D = source to film distance, mm, and
ϕ = ϕfocal spot size, mm.
The distance shall be not less than 1 m (39.4 in.).

6.2 See the physical set up as shown in Fig. 2. Position the X-ray tube directly over the center of the test specimen and film. The plane of the film and test specimen must 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.

6.3 *Exposure*:

6.3.1 Expose the film at the kV setting as determined in Section 4. Remove all copper filters at the tube before the exposure. Adjust the exposure time to give a film density of $2.00 \pm {}^{0.10}_{0.00}$ in the center of the film as measured with a densitometer calibrated with a density step wedge traceable to National Institute of Standards and Technology, (NIST).

6.3.2 Make three separate exposures using the same film cassette each time.

6.3.3 Identify the film number, type, exposure, and other technique data by means of lead letters, or numerals, placed in the upper righthand corner of the steel plate. Do not place so as to interfere with the image of the holes in the IQI. Make these identification symbols as small and unobtrusive as possible. Record this identification number on the data sheet for this exposure (see Section 7).

6.3.4 In order to minimize any effects caused by latent image instability, process the exposed film not more than 8 h after exposure.

6.4 *Processing*—The image quality response of the film may vary with the processing variables such as chemistry, temperature, and method of processing (manual or automatic). The solutions must be fresh and properly seasoned (see 6.4.1).

6.4.1 *Automatic Processing*—Use industrial X-ray processing solutions in the tests. Keep a record of:

6.4.1.1 The brand name of the processor.

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

6.4.1.3 The brand name of the developer, including the" starter," the temperature measured to within 0.5°C, and the rate

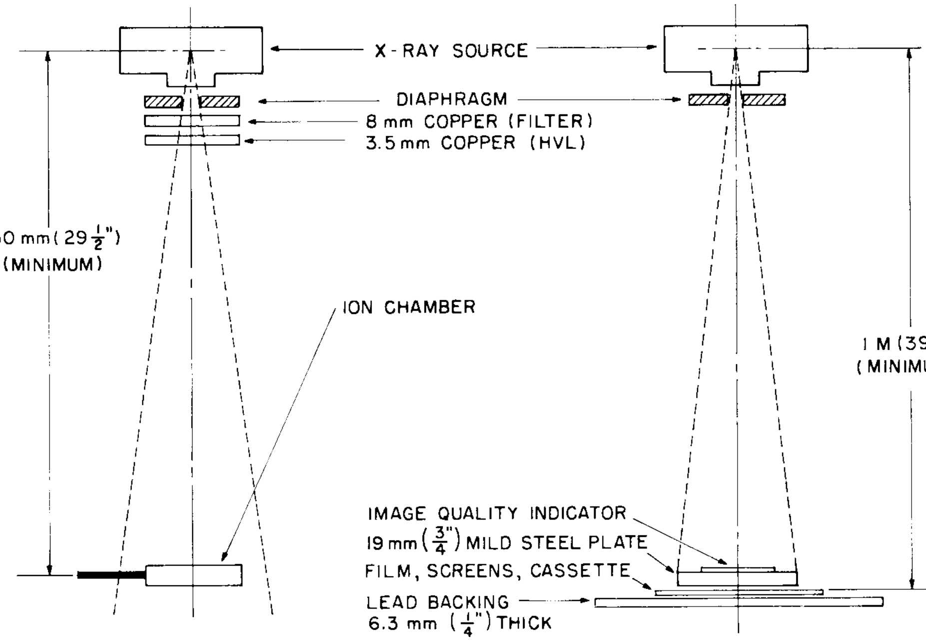


FIG. 2 Setup for Energy Calibration and Exposures

of replenishment to within ±5 %.

6.4.1.4 The brand name and total quantity of film used in seasoning fresh developer solution before processing test films. Process a minimum of ten film (360 by 430-mm (14 by 17-in.)) per gallon of developer; half flash each sheet to a maximum density by white light. An acceptable alternative to half flashing each sheet is to flash alternate sheets fully in equal numbers.

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

6.4.2.1 The time of development (±2 s).

6.4.2.2 The temperature of developer measured within 0.5°C.

6.4.2.3 The brand name and the total quantity of film used in seasoning the fresh developer solution before processing test films. Process a minimum of four 360 by 340-mm (14 by 17-in.) sheets of film per gallon of developer solution; half flash each sheet of film to maximum density by white light before processing or use alternative method (see 6.4.1.4).

7. Data Collection and Evaluation

7.1 The three test films for any one film type shall be read independently by three readers. Each reader shall record the number of holes of a given size visible on each step of the IQI. The viewing box should be masked to prevent stray light from distracting the reader, and the room should be darkened with minimal background lighting. A magnifier up to 3× is permitted. A sample data sheet is shown in Fig. 3.

7.2 *Data Evaluation*—The data is evaluated by calculating the sum of the number of holes of a given size visible on each step. The sum is based upon three readers and three radiographs. Convert the step/hole size to equivalent penetrameter sensitivity (EPS) as follows:

$$\text{EPS, \%} = \frac{100}{X} \times \sqrt{\frac{Th}{2}}$$

where:

h = hole diameter, mm,
T = step thickness of IQI, mm, and
X = thickness of test object, mm.

The number of detectable holes versus the equivalent penetrameter sensitivity is plotted for each step of the IQI and for each film type as shown in Fig. 4. The image quality response is determined for the point where 50 % of the holes are visible. This value is the classification index for the film under test.

7.2.1 *Alternate-One Method for Data Evaluation*—In addition to the curve plotting method described in 7.2, the classification index may be calculated mathematically between two adjacent 30 hole rows by interpolating between the EPS values of the row with more than 15 visible holes and the row with less than 15 visible holes by use of the formula:

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

where:

C = the classification index (the midpoints or 50 % point) on the graph (Fig. 4).
N_a = the total number of visible holes in the row immediately above the midpoint and Q_a is the corresponding EPS value.
N_b = the total number of visible holes in the row immediately below the midpoint and Q_b is the corresponding EPS value.

The following example is given for illustration—A row having 23 visible holes has an EPS value of 1.57. An adjacent row has 12 visible holes and an EPS value of 1.49.

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

$$C = 1.51$$

7.2.2 *Alternate-Two Method for Data Evaluation*—In addition to the curve plotting method described in 7.2, the data may

Date ____________

1. Film and Exposure Data:

Lab. ____________

Film Type ____________ Reader ____________

Kilovoltage: ____________

Source to Film Distance ________ mAS ________ Source Size ________

Screens: Front ____________ Back ____________

Remarks: ____________

PROCESSING

Automatic		Manual	
Name	________	Developer Type	________
Developer Type	________	Developer Temp.	________
Developer Temp.	________	Developer Time	________
Developer Time	________	Seasoning	________
Developer Rep. Rate	________		
Seasoning	________		

Interpretation IQI Step Size	Hole Size	EPS(%)	Number of Holes Visible Expos. #1	Expos. #2	Expos. #3
.38 mm (.015")	.71 mm (.028")	1.92			
"	.64 mm (.025")	1.82			
"	.58 mm (.023")	1.71			
.25 mm (.010")	.79 mm (.031")	1.66			
"	.71 mm (.028")	1.57			
"	.64 mm (.025")	1.49			
.20 mm (.008")	.71 mm (.028")	1.41			
"	.64 mm (.025")	1.33			
"	.58 mm (.023")	1.25			
.13 mm (.005")	.81 mm (.032")	1.19			
"	.71 mm (.028")	1.12			
"	.64 mm (.025")	1.05			
"	.58 mm (.023")	1.00			
"	.50 mm (.020")	0.94			

FIG. 3 Data Sheet

be evaluated by averaging the number of holes of a given size (hole set) visible on each plaque image of the IQI for a given film type. This average is based on the evaluation by three readers of three radiographs of each film type. This same averaging procedure is repeated for each hole set. The number of visible holes for each different hole set is then summed. This sum is the visibility index for each film type and is a measure of the relative image quality response of a given film type. This method of evaluating the relative image quality response for different film types is illustrated in Table 1.

8. Keywords

8.1 Image Quality Indicator; IQI; penetrameter; radiographic film

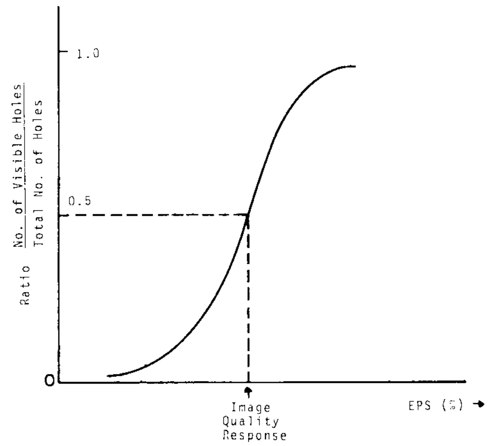


FIG. 4 Visibility versus EPS Values

TABLE 1 Average Number of Visible Holes

Film Type	Hole Set 1	2	3	4	5	6	7	8	9	Visibility Index
1	30	30	30	23	12.7	0	0	0	0	125.7
2	30	27.7	25.2	12.2	0	0	0	0	0	95.1
3	30	26.5	21.7	8.7	0	0	0	0	0	86.9
4	30	25.2	15.7	5.3	1	0	0	0	0	76.2