Designation: E242 – 15 (Reapproved 2020)

Standard Reference Radiographs for Appearances of Radiographic Images as Certain Parameters are Changed[1]

This standard is issued under the fixed designation E242; 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 document describes the appearance of a radiographic image where fundamental components of image quality are changed, that is, variables such as whether an X-ray or gamma ray source was used, the characteristics of the radiographic film (gradient, granularity, and developing conditions) and intensifying screens, and specimen thickness (the geometrical configuration of the radiographic set-up and focal spot size both affect image quality but are not considered in the reference radiographs).

1.2 The X-ray film systems used in obtaining the illustrative data were as follows: Very Fine Grain (comparable to class I of Test Method E1815) and Fine Grain (comparable to class II of Test Method E1815).

1.3 These reference radiographs[2] consist of four composite illustrations[3] and show how such factors as radiation energy, specimen thickness, and film properties affect the radiographic image. The reference radiograph films are an adjunct to this document and must be purchased separately from ASTM if needed.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

E94 Guide for Radiographic Examination Using Industrial Radiographic Film

E746 Practice for Determining Relative Image Quality Response of Industrial Radiographic Imaging Systems

E1316 Terminology for Nondestructive Examinations

E1735 Practice for Determining Relative Image Quality Response of Industrial Radiographic Imaging Systems from 4 to 25 MeV

E1815 Test Method for Classification of Film Systems for Industrial Radiography

2.2 *ASTM Adjuncts:*

Reference Radiographs for Appearances of Radiographic Images as Certain Parameters Are Changed[3]

3. Terminology

3.1 *Definitions:* For definitions of terms used in this document, see Terminology E1316, Section D.

4. Significance and Use

4.1 A key consideration with any radiographic system is its contrast resolution and spatial resolution capability (that is, sensitivity). The degree of obtainable sensitivity with a given system is dependent upon several radiographic parameters such as source energy level, film system class, type and thickness of intensifying screens, and material thickness radiographed. These reference radiographs permit the user to estimate the degree of sensitivity change that may be obtained when these parameters are varied from a specific technique. This standard may also be used in conjunction with Test Method E1815 or with Practice E746 or Test Method E1735 to provide a basis for developing data for evaluation of a user's specific system. This

[1] These reference radiographs are under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and are the direct responsibility of Subcommittee E07.02 on Reference Radiological Images.

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[2] For ASME Boiler and Pressure Code applications, see related Reference Radiographs SE-242 in the Code.

[3] Available from ASTM Headquarters. Order RRE0242.

[4] 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.

*A Summary of Changes section appears at the end of this standard

data may assist a user in determining appropriate parameters for obtaining desired degrees of radiographic system sensitivity.

5. Factors Affecting Radiographic Appearance

5.1 The final interpretation of the radiograph is greatly affected by the appearance of a discontinuity. A poor technique can minimize the radiographic appearance of a discontinuity and conversely the optimum technique can emphasize this appearance. The appearance of a radiographic image is affected mainly by:

5.1.1 X-ray or gamma ray energy,
5.1.2 Section thickness,
5.1.3 Unsharpness,
5.1.4 Film and screen combinations, and
5.1.5 Film system class.

5.2 An equation that considers most of the above factors (excluding unsharpness) is:

$$\Delta x = \left[c\left(d_1 - d_2\right)/G\mu\right](kx+1) \quad (1)$$

where:

Δx = thickness of discontinuity,
c = constant,
$d_1 - d_2$ = minimum density change perceptible by eye,
G = film gradient,
μ = linear absorption coefficient (effective),
k = scattering coefficient, and
x = section thickness.

The minimum density change, perceptible by eye, depends on the film system class used, the geometric unsharpness, and the attenuation by the material. The thickness-dependent contrast sensitivity, CS, in % (equivalent penetrameter sensitivity) of section thickness for 2T hole plate IQIs is described as follows:

$$CS_{\%\ thickness} = (PT/x) \times ((\sigma_D\ \ Ug)/(G\ \ \mu_{eff}))^{1/2} \quad (2)$$

where:

PT = constant perception threshold for human operators,
σ_D = film granularity,
Ug = geometric unsharpness, and
μ_{eff} = μ/(kx+1).

NOTE 1—Gradient over granularity (G/σ_D) increases by a factor of three from film class III to Special Class (see Test Method E1815). The contrast sensitivity improves by 1.7.

As the above equations show, the minimum thickness of detectable discontinuity (Δx or CS) is:

5.2.1 A function of X-ray energy and scatter,
5.2.2 A function of section thickness,
5.2.3 An inverse function of film gradient and attenuation coefficient, and
5.2.4 A function of the film system class and geometric unsharpness.

5.3 These reference radiographs do not consider the effects of unsharpness other than due to specimen thickness.

6. Radiographic Illustrations

6.1 A series of 36 radiographs, each on 10-in. by 12-in. [254-mm by 305-mm] film, were taken of a 12-in. by 12-in. [305-mm by 305-mm] welded steel plate which contained discontinuities in the weld. These were taken to illustrate the differences in appearance of the radiographic image when techniques for taking radiographs are varied by changing the factors listed in Section 5. Technique data for each radiograph is in Table 1. A 2-in. by 2-in. [51-mm by 51-mm] area, which includes the identical image of the discontinuities in the weld, was selected and cut out from each 10-in. by 12-in. [254-mm by 305-mm] radiograph and arranged so as to make four composite illustrations identified as Figures 1 through 4. These

TABLE 1 Technique Data

NOTE 1—No radiographic geometry or focal spot size information is available.

Source	Lead Screens		Composite Illustration				Film	Notes
			A	B	C	D		
			Steel Thickness					
	Front, in.	Back, in.	1 in. [25 mm]	2 in. [51 mm]	4 in. [102 mm]	6 in. [152 mm]		
150 kVp	0.005	0.005	x	...	...	...	Fine grain	¼ in. lead mask
250 kVp	0.005	0.005	...	x	...	...	Fine grain	¼ in. lead mask
1 MeV	0.030	0.010	x	x	x	...	Very fine grain	...
	0.030	0.010	...	...	...	x	Fine grain	...
	0.005	0.005	x	x	x	...	Fine grain	...
2 MeV	0.030	0.010	x	x	x	x	Very fine grain	...
	0.005	0.005	x	x	x	x	Fine grain	...
10 MeV	0.040	0.010	x	x	x	x	Fine grain	...
15 MeV	0.030	0.010	x	x	x	x	Very fine grain	...
Iridium 192	0.005	0.010	x	...	...	...	Fine grain	...
	0.010	0.010	...	x	x	...	Fine grain	...
Cobalt-60 (2½ Ci)	0.005	0.010	x	...	...	...	Fine grain	...
	0.010	0.010	...	x	x	...	Fine grain	...
Cobalt-60 (1000 Ci)	0.010	0.010	...	...	x	x	Fine grain	0.080 in. lead filter
Radium-226 (250 mg)	0.010	0.010	x	x	x	...	Fine grain	...