INTERNATIONAL

Designation: E 242 – 95 (Reapproved 2000)

Designation: E 242 – 01

An American National Standard

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

This standard is issued under the fixed designation E 242; 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] These reference radiographs are under the jurisdiction of ASTM Committee E-7 E07 on Nondestructive Testing and are the direct responsibility of Subcommittee E07.02 on Reference Radiographs.

Current edition approved Dec. June 10, 1995. 2001. Published February 1996. August 2001. Originally published as E 242 – 64 T. Last previous edition E 242 – 915 (2000).

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 and intensifying screens, and the geometrical configuration of the object under investigation as well as its associated radiographic set-up.

1.2 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.

1.3 The values stated in inch-pound units are to be regarded as the standard.

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:*

E 94 Guide for Radiographic Testing Examination[4]

E 746 Test Method for Determining Relative Image Quality Response of Industrial Radiographic Film[4]

E 1316 Terminology for Nondestructive Examinations[4]

E 1815 Test Method for Classification of Film Systems for Industrial Radiography[4]

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 E 1316, Section D.

4. Significance and Use

4.1 A key consideration with any radiographic system is its capability to resolve detail (that is, sensitivity). The degree of obtainable sensitivity with a given system is dependent upon several radiographic parameters such as source energy level, film type, system, 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 E 1815 or with Test Method E 746 to provide a basis for developing data for evaluation of a user's specific system. This 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:

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

5.1.1 X-ray or gamma ray energy.
5.1.2 Section thickness,
5.1.3 Unsharpness, and
5.1.4 Film and screen combinations.
5.2 The equation that considers most of the above factors is:

$$\Delta x = [c(d_1 - d_2)/G\mu](kx + 1) \tag{1}$$

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.

As the above equation shows, the minimum thickness of detectable discontinuity (Δx) is:
5.2.1 A function of X-ray energy,
5.2.2 A function of section thickness, and
5.2.3 An inverse function of film gradient.
5.3 Although not clearly indicated by the above relation, the size of detectable discontinuity is also a function of unsharpness, see Guide E 94.

6. Radiographic Illustrations

6.1 A series of 36 radiographs, each on 10 by 12-in. (254 by 305-mm) film, were taken of a 12 by 12 in. 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. A 2 by 2 in. (51 by 51 mm) area, which includes the identical image of the discontinuities in the weld, was selected and cut out from each 10 by 12 in. radiograph and arranged so as to make four composite illustrations identified as Fig. 1 through Fig. 4. These composite illustrations are an abridged version of the original 36 radiographs and serve as the reference radiographs for this document. Following are brief descriptions of these figures.

6.1.1 *Figure 1—Composite Illustration A* consists of cut outs from the 10 radiographs taken of the 1-in. (25-mm) thick welded steel plate.

6.1.2 *Figure 2—Composite Illustration B* consists of cut outs from the 10 radiographs taken of the welded steel plate, built up to 2 in. in thickness.

6.1.3 *Figure 3—Composite Illustration C* consists of cut outs from the 10 radiographs taken of the welded steel plate, built up to 4 in. in thickness.

6.1.4 *Figure 4—Composite Illustration D* consists of cut outs from the 6 radiographs taken of the welded steel plate, built up to 6 in. (152 mm) in thickness.

6.2 The radiographic appearance of discontinuities in 1, 2, 4, and 6-in. thick steel is shown in the series of composite radiographs. (These are full-scale reproductions of the same selected area from all the reference radiographs.) All composite sets of radiographs show the change in radiographic appearance in the specified thickness of steel plate as the parameters of X-ray or gamma ray energy and film ~~types~~ systems or both are changed.

6.3 *Film Deterioration*—Radiographic films are subject to wear and tear from handling and use. The extent to which the image deteriorates over time is a function of storage conditions, care in handling and amount of use. Reference radiograph films are no exception and may exhibit a loss in image quality over time. The radiographs should therefore be periodically examined for signs of wear and tear, including scratches, abrasions, stains, and so forth. Any reference radiographs which show signs of excessive wear and tear which could influence the interpretation and use of the radiographs should be replaced.

7. Use of the Reference Radiographs

7.1 As radiation energy increases, the radiographic appearance of a given discontinuity becomes less distinct because of the greater penetration of the radiation; that is, because of decreasing subject contrast. The reference radiographs permit a comparison of the radiographic appearance of the weld, at particular thickness over a range of X-ray or gamma ray energies.

7.2 Another condition that affects radiographic appearance is the variation of thickness for a given X-ray or gamma ray energy. As the thickness of ~~inspected~~ examined material is increased, a discontinuity becomes less distinct in the radiographic image. This is due to two predominant factors:

7.2.1 The X-ray or gamma ray beam divergence which produces unsharpness on the film when traversing a large thickness.

7.2.2 Scattered radiation within the material, which reduces the radiographic contrast.

7.2.3 The above processes are a function of material thickness and X-ray or gamma ray energy. This effect is illustrated in this document by the composite set of radiographs or by direct reference to the full-size radiographs.

8. Film and Screens

8.1 The X-ray film systems used in obtaining the illustrative data were ~~of two types:~~ as follows: Very Fine Grain (comparable to class I of Test Method E 1815) and Fine Grain ~~(Guide E 94).~~ (comparable to class II of Test Method E 1815). Comparisons of these two ~~types of~~ film systems are illustrated in the composite ~~radiographs.~~

~~8.2 Several different lead foil screen combinations were used. The specific combination of lead foil screens for each radiograph is noted in~~ radiographs and within Table 1.

8.2 Several different lead foil screen combinations were used. The specific combination of lead foil screens for each radiograph is noted in Table 1.

9. Conclusions and Summary

9.1 For a constant specimen thickness, the radiographic appearance of the discontinuities changes as the X-ray or gamma ray energy is varied.

9.2 As the section thickness of specimen increases, the radiographic appearance of the discontinuities becomes less distinct, the radiation energy remaining constant.

9.3 All other factors remaining constant, as the film is changed from very fine grain (class I of Test Method E 1815) to fine grain (class II of Test Method E 1815), the radiographic appearance of the discontinuities becomes less distinct.

9.4 For specimens of uniform thickness, these data reveal that the most distinct radiographic appearance of the discontinuities occurs when the finest grain film and the lowest X-ray or gamma ray energy is used, consistent with a given specimen thickness and practical exposure time.

10. Keywords

10.1 film ~~types;~~ systems; discontinuities; gamma rays; reference radiographs; steel; unsharpness; welds; x-ray

EXPLANATORY NOTES

NOTE 1—Total unsharpness factors such as source size, source-film distance, screens, film graininess, etc., must be considered in establishing techniques (Guide E 94).

NOTE 2—It is not the intent of this document to limit the usefulness of any source of radiation. ~~At a later date, Type I Film may be explored to complete the work at other energy levels.~~ The radiographs included in this document are illustrative and not intended to be either inclusive or conclusive.

TABLE 1 Technique Data

NOTE 1—1 in. = 25.4 mm.

Source	Lead Screens		Composite Illustration				Film	Notes
			A	B	C	D		
			Steel Thickness					
	Front, in.	Back, in.	1 in.	2 in.	4 in.	6 in.		
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 MV	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 MV	0.030	0.010	x	x	x	x	Very fine grain	...
	0.005	0.005	x	x	x	x	Fine grain	...
10 MV	0.040	0.010	x	x	x	x	Fine grain	...
15 MV	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 C)	0.005	0.010	x	...	...	...	Fine grain	...
	0.010	0.010	...	x	x	...	Fine grain	...
Cobalt-60 (1000 C)	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	...

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL TECHNICAL INFORMATION

X1.1 Radiation source was centered over drilled hole in center of specimen (as seen in the 10 in. by 12 in. (254 by 305 mm) full-size reproduction). In 1 MV and 2 MV radiography, the radiation was projected towards the specimen through the target, using a transmitted beam.

X1.2 Radiographic exposure was such that the film density in the radiograph at the center of a line connecting the image of the two drilled holes in the plate was between 1.90 and 2.10.

X1.3 All films were developed using procedures recommended in Guide E 94.

X1.4 Good contact between film and screens was maintained.