

Questions and Answers

Levels I, II, and III

Radiographic Testing Method

*Supplement to
Recommended Practice
No. SNT-TC-1A
Book A*



The American Society
for Nondestructive Testing, Inc.

Level III Answers
Radiographic Testing Method

- | | | | | | | | |
|----|---|----|---|----|---|----|---|
| 1. | d | 3. | c | 5. | c | 7. | b |
| 2. | c | 4. | c | 6. | c | | |

Published by
The American Society for Nondestructive Testing, Inc.
1711 Arlington Lane
PO Box 28518
Columbus, OH 43228-0518

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ISBN-13: 978-0-931403-45-3

Printed in the United States of America

first printing 1980
second printing 11/87
third printing 03/88
fourth printing 09/89
fifth printing 04/90
sixth printing 12/91
seventh printing with revision 04/96
eighth printing 05/99
ninth printing 03/05
10th printing 02/07

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Sample Specification Questions

Radiographic Testing Method

Using the Sample Specification located on pages 71-72, answer the remaining questions. (References listed pertain to paragraphs in the sample specifications.)

1. A 13 mm (0.5 in.) stainless steel plate weld with 3 mm (0.125 in.) outside reinforcement ground flush on the back side was radiographed. Which of the following would be acceptable according to the specification?

- a. 250 kV-91 cm (36 in.) FFD – #10 penetrameter
- b. 100 Ci Ir-192-61 cm (24 in.) FFD – #12 penetrameter
- c. 400 kV-61 cm (24 in.) FFD – #10 penetrameter
- d. none of the above

Para. 6.7

2. The following parameters were used when radiographing a 22 mm (0.88 in.) thick plate weld with 3 mm (0.13 in.) reinforcement on the front and back side.

Source – 100 Ci Ir-192	Screens – 0.010 F/B
FFD – 61 mm (24 in.)	Penetrameter – #20
Film – Class IV	Shim – 6 mm (0.250 in.)

This technique relative to the specification would result in:

- a. an acceptable radiograph
- b. an excessive amount of unsharpness
- c. an unacceptable radiograph
- d. a radiograph showing poor contrast

Para. 5.0

Based on the specification requirements, determine the adequacy of the following techniques

3. A 41 mm (1.6 in.) thick plate weld, with 32 mm (0.13 in.) outside reinforcement and 102 mm (4 in.) thick backing bar, is to be radiographed. Select the proper combination of parameters.

- a. 400 kV – 61 mm (24 in.) FFD – #45 penetrameter
- b. 100 Ci Ir-192 – 76 cm (30 in.) FFD – #30 penetrameter
- c. 1 MeV – 72 in. FFD – #40 penetrameter
- d. 25 Ci Co-60 – 51 cm (20 in.) FFD – #25 penetrameter

Table II

4. From the preceding question, what would be the recommended shim thickness?

- a. 13 mm (0.5 in.)
- b. 6 mm (0.25 in.)
- c. 10 mm (0.38 in.)
- d. 3 mm (0.13 in.)

Para. 6.7

5. The density through the penetrameter was recorded 1.8 (H&D double viewing). Which of the following readings or statements is correct for this exposure?

- a. 1.53 to 2.07 (H&D) through area of interest
- b. 1.44 to 2.16 (H&D) through area of interest
- c. unacceptable technique
- d. double viewing of film is required

Para. 7.0

6. The following discontinuities were noted on the radiograph of a 51 mm (2 in.) thick carbon steel plate.

Slag (3) 3 mm (0.13 in.), (2) 6 mm (0.25 in.), (1) 11 mm (0.44 in.) Porosity (4) 3 mm (0.13 in.).

Which of the following statements would constitute the appropriate method of disposition of these conditions?

- a. accept
- b. remove (4) 3 mm (0.13 in.) indications, repair, and reexpose
- c. remove the 11 mm (0.44 in.) slag inclusion, repair weld, and reexpose
- d. remove the (3) 3 mm (0.13 in.) porosity and (2) 3 mm (0.13 in.) slag inclusions, repair weld, and reexpose

Para. 10.1

7. If the density through the penetrameter was found to be 3.5 (H&D), which of the following statements would be *correct* for this technique and single-wall viewing?

- a. minimum density 2.98, maximum density 4.55
- b. minimum density 2.98, maximum density 3.80
- c. minimum density 2.45, Maximum density 3.80
- d. none of the above

Para. 7.0

- 6.6 Penetrameter Placement: source side of object being examined 3.2 mm (0.13 in.) to 19 mm (0.75 in.) from edge of weld at the extremities.
- 6.7 Shims: as required to have the same nominal thickness under the penetrameter, as the total thickness of the weld plus reinforcement or backing strips. Backing strips or bars are not to be considered as part of the weld or reinforcement, for determination of penetrameter size.

7.0 Density:

Single film viewing – 2.0 to 3.8
Double film viewing – 2.6 to 3.8
The density of the radiograph shall not vary by more than minus 15 percent or plus 30 percent from the density through the body of the penetrameter.

8.0 Sensitivity:

The essential hole (2T) and the image of the penetrameter shall be visible.

9.0 Film Processing:

Manual or automatic processing is acceptable.

10.0 Acceptance Criteria:

- 10.1 All welds and adjacent base material shall be free of:
- A. cracks
 - B. incomplete penetration
 - C. incomplete fusion
 - D. slag inclusions in 15 cm (6 in.) of length mat. thick:
 - 6 to 13 mm (0.25 to 0.5 in.) – inclusions exceeding 3 mm (0.13 in.)
 - 13 to 25 mm (0.5 to 1 in.) – inclusions exceeding 6 mm (0.25 in.)
 - 25 to 51 mm (1 to 2 in.) – inclusions exceeding 10 mm (0.38 in.)
 - E. burn through
 - F. porosity – in 15 cm (6 in.) of length in excess of:
 - mat. thick:
 - 6 to 13 mm (0.25 to 0.5 in.) – (4) 0.06 mm 2 mm (0.06 in.)
 - 13 to 25 mm (0.5 to 1 in.) – (4) 2 mm (0.06 in.), (2) 2 mm (0.09 in.)
 - 25 to 51 mm (1 to 2 in.) – (4) 3 mm (0.13 in.)

Recommended Training References
Radiographic Testing Method

The following references were used in formulating the questions contained in this book.

- A.* McMaster, R.C., ed. *Nondestructive Testing Handbook*, first edition. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1959. Sections 13-26 (pgs. 13.1-26.18).
- B.* McGonnagle, Warren J. *Nondestructive Testing*, second edition. New York: Gordon & Breach. 1977.
- C.* *Annual Book of ASTM Standards*, Volume 03.03, *Nondestructive Testing*. “Standard Guide for Radiographic Testing.” Standard ASTM E 94. “Standard Method for Controlling Quality of Radiographic Testing.” Standard ASTM E 142, and “Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology.” Standard ASTM E 1025. Philadelphia, PA: American Society for Testing and Materials. Latest edition.
(Reference numbers after the questions contain the standard number in them. Example: CE94.)
- D. Richardson, Harry D. *NDT Radiography Training Manual*. Wilmington, DE. E. I. du Pont de Nemours and Co. 1968, reprint.
- E.* *Radiographic Testing: Classroom Training Handbook (CT-6 6)*. San Diego, CA: General Dynamics/Convair Division. 1967. (Now published by The American Society for Nondestructive Testing, Inc.)
- F.* *Radiography in Modern Industry*, fourth edition. Rochester, NY: Eastman Kodak Co. 1980.
- G.* *Metals Handbook*, eighth edition, *Nondestructive Inspection and Quality Control*, Volume 11. Metals Park, OH: American Society for Metals. 1976.
- H.* Halmshaw, R. *Industrial Radiology Techniques*. New York: Springer-Verlag. 1971.
- *Available from The American Society for Nondestructive Testing, Inc.

Each question found in this book contains letter(s) and page number(s) in bold type and sometimes chapter or section number(s) immediately following the answers. For example,

35. In comparison with lower-voltage radiographs, high-energy radiographs show:

- a. greater contrast
- b. greater latitude
- c. greater amounts of scatter radiation relative to primary beam intensity
- d. none of the above

A.23.4-5

In this example, the letter “A” refers to Reference A in the list provided above. The number “23” refers to the section or chapter number in Reference A and the “4-5” is the page range in Reference A where the answer to the question can be found.

Historical References

Clark, G. L. *Applied X-Rays*. New York: McGraw-Hill. 1955.

Clauser, H. R. *Practical Radiography for Industry*. New York: Rheinhold Publishing Corporation. 1952.

Crowther, J. A. *Handbook of Industrial Radiography*. London: Edward Arnold and Co. 1949.

Sproull, W. T. *X-Rays in Practice*. New York: McGraw-Hill. 1946.

St. John, A., and H. R. Isenburger. *Industrial Radiology*. New York: John Wiley & Sons. 1943.

Wiltshire, W. J. *A Further Handbook of Industrial Radiography*. London: Edward Arnold and Co. 1957.

Reference Usage List Radiographic Testing Method

Reference A: Total = 255	Reference E: Total = 46
Level I (67)	Level I (9)
Level II (88)	Level II (13)
Level III (100)	Level III (24)
Reference B: Total = 9	Reference F: Total = 197
Level I (2)	Level I (51)
Level II (1)	Level II (48)
Level III (6)	Level III (98)
Reference C: Total = 16	Reference G: Total = 23
Level I (3)	Level I (1)
Level II (3)	Level II (0)
Level III (10)	Level III (22)
Reference D: Total = 60	Reference H: Total = 22
Level I (12)	Level I (0)
Level II (12)	Level II (0)
Level III (36)	Level III (22)

Sample Specification Radiographic Testing Method

- 1.0 Scope:

This specification is to be used for the radiographic examination of butt welds in 6 to 51 mm (0.25 to 2 in.) thick plate.
- 2.0 Material:

Carbon steel
- 3.0 Surface Requirements:

Prepared mechanically to eliminate surface irregularities whose image could interfere with proper interpretation.
- 4.0 Radiation Source:

X- or gamma radiation—as specified in Table I
- 5.0 Film:

Type II (Fine grain) or better.

Material Thickness	Voltage (Max.)	Ir-192 (Max.)	Co-60 (Max.)
6.4 mm to less than 19 mm (0.25 in. to less than 0.75 in.)	400 kV	1.9 TBq (50 Ci)	
19 mm to less than 38 mm (0.75 in. to less than 1.5 in.)	2 MeV	3.7 TBq (100 Ci)	
38 mm to 51 mm (1.5 in. to 2 in.)	4 Mev	3.7 TBq (100 Ci)	3.7 TBq (100 Ci)

- 6.0 Technique:

6.1 Single wall, utilizing single or double film viewing of finished radiographs.

6.2 Film Focal Distance: a minimum of 6.1 cm (24 in.) FFD shall be maintained.

6.3 Screens: lead intensification screens should be used for all exposures.

6.4 Scatter Indicator: A 13 mm (0.5 in.) high by 1.6 mm (0.06 in.) thick lead letter "B" attached to the back of the cassette.

6.5 Penetrators: the applicable penetrometer shall be based on the nominal single wall thickness plus reinforcement selected from Table II.
- | Nominal Single Wall Material Thickness | Penetrater | Thickness | Essential Hole | Diameter |
|--|------------|---------------------|----------------|---------------------|
| mm (in.) | | | | |
| Up to 6 mm (0.25 in.) | 7 | 0.2 mm (0.007 in.) | 2T | 0.51 mm (0.02 in.) |
| 6-9.5 mm (0.25-0.38 in.) | 10 | 0.25 mm (0.01 in.) | 2T | 0.51 mm (0.02 in.) |
| 9.5-13 mm (0.38-0.5 in.) | 12 | 0.31 mm (0.012 in.) | 2T | 0.64 mm (0.025 in.) |
| Over 13-16 mm(0.5-0.63 in.) | 15 | 0.38 mm (0.015 in.) | 2T | 0.76 mm (0.03 in.) |
| Over 16-19 mm (0.63-0.75 in.) | 17 | 0.43 mm (0.017 in.) | 2T | 0.89 mm (0.035 in.) |
| Over 19-22 mm (0.75-0.9 in.) | 20 | 0.51 mm (0.02 in.) | 2T | 1 mm (0.04 in.) |
| Over 22-25 mm (0.9-1 in.) | 25 | 0.64 mm (0.025 in.) | 2T | 1.3 mm (0.05 in.) |
| Over 25-32 mm (1-1.25 in.) | 30 | 0.76 mm (0.03 in.) | 2T | 1.5 mm (0.06 in.) |
| Over 32-38 mm (1.25-1.5 in.) | 35 | 0.89 mm (0.035 in.) | 2T | 1.8 mm (0.07 in.) |
| Over 38-51 mm (1.5-2 in.) | 40 | 1 mm (0.04 in.) | 2T | 2 mm (0.08 in.) |
| Over 51-64 mm (2-2.5 in.) | 45 | 1.1 mm (0.045 in.) | 2T | 2.3 mm (0.09 in.) |
- 6
- 71

153.	c	186.	c	219.	b	252.	d
154.	c	187.	d	220.	a	253.	c
155.	b	188.	b	221.	d	254.	b
156.	d	189.	d	222.	a	255.	a
157.	a	190.	a	223.	b	256.	d
158.	d	191.	c	224.	a	257.	a
159.	c	192.	c	225.	b	258.	d
160.	b	193.	c	226.	d	259.	c
161.	b	194.	c	227.	b	260.	a
162.	d	195.	a	228.	a	261.	c
163.	a	196.	d	229.	d	262.	d
164.	d	197.	b	230.	b	263.	b
165.	a	198.	b	231.	c	264.	b
166.	a	199.	b	232.	c	265.	d
167.	d	200.	c	233.	b	266.	c
168.	b	201.	b	234.	a	267.	b
169.	c	202.	b	235.	c	268.	a
170.	b	203.	d	236.	a	269.	d
171.	b	204.	c	237.	c	270.	c
172.	d	205.	c	238.	d	271.	a
173.	c	206.	a	239.	b	272.	d
174.	a	207.	d	240.	d	273.	b
175.	b	208.	d	241.	d	274.	c
176.	d	209.	c	242.	c	275.	a
177.	c	210.	c	243.	c	276.	d
178.	a	211.	b	244.	c	277.	c
179.	b	212.	a	245.	d	278.	b
180.	c	213.	b	246.	a	279.	a
181.	b	214.	c	247.	a	280.	d
182.	a	215.	d	248.	b	281.	c
183.	d	216.	b	249.	a	282.	b
184.	a	217.	d	250.	b	283.	a
185.	b	218.	c	251.	b		

Level I Questions

- | | | |
|---|--|------------------|
| 1. Although there may be other reasons for using calcium tungstate screens in industrial radiography, they are most usually used to: | a. improve definition and resolution in radiographic images
b. improve contrast in radiographic images
c. decrease exposure time
d. make films respond to multimillion volt radiation | F.36 |
| 2. An excellent radiograph is obtained under given conditions of exposure with the film located at a distance of 91 cm (36 in.) from the target of the X-ray tube. If the film is now placed only 46 cm (18 in.) from the target, and all exposure conditions except time are held constant, the new exposure time will be: | a. unchanged
b. longer by approximately 80 percent
c. shorter by approximately 55 percent
d. only about 25 percent as long as the original exposure time | F.47 |
| 3. An excellent radiograph is obtained under given exposure conditions with a tube current of 5 mA and an exposure time of 12 minutes. If other conditions are not changed, what exposure time would be required if the X-ray tube current could be raised to 10 mA? | a. 24 minutes
b. 12 minutes
c. 6 minutes
d. 3 minutes | F.49 |
| 4. In film radiography, penetrameters are usually placed: | a. between the intensifying screen and the film
b. on the source side of the test object
c. on the film side of the test object
d. between the operator and the radiation source | A.13.31 |
| 5. When radiographing to the 2-2T quality level, an ASTM penetrometer for 13 mm (0.5 in.) thick 2024 aluminium alloy has a thickness of: | a. 13 mm (0.5 in.)
b. 5×10^{-5} m (2 mils)
c. 13×10^{-5} m (5 mils)
d. 25×10^{-5} m (10 mils) | C.E142-77 |
| 6. The penetrating ability of an X-ray beam is governed by: | a. kilovoltage
b. time
c. milliamperage
d. source-to-film distance | A.20.15 |
| 7. Co-60 used in nondestructive testing emits: | a. alpha particles
b. neutrons
c. gamma rays
d. X-rays | A.15.14 |
| 8. A densitometer is an instrument for measuring: | a. X-ray intensity
b. film density
c. density of a material
d. tube current | A.20.32 |
| 9. Three liquids which are essential to process an exposed film properly are: | a. stop bath, acetic acid, and water
b. developer, stop bath, and H_2O_2
c. developer, fixer, and water
d. acetic acid, fixer, and stop bath | A.21.1 |

10. The two most common causes for excessively high-density radiographs are:

a. insufficient washing and overdevelopment

b. contaminated fixer and insufficient washing

c. overexposure and contaminated fixer

d. overexposure and overdevelopment

A.21.18

11. The time required for one-half of the atoms in a particular sample of radioactive material to disintegrate is called:

a. the inverse square law

b. a curie

c. a half-life

d. the exposure time

A.15.1, 15.5

12. What does the term R/h refer to when speaking of intensity?

a. radiation limits for humans

b. roentgens per hour

c. X-rays per hour

d. radiation in hydrogen

A.15.5

13. The ability to detect a small discontinuity or flaw is called:

a. radiographic contrast

b. radiographic sensitivity

c. radiographic density

d. radiographic resolution

A.15.30

14. Movement, geometry, and screen contact are three factors that affect radiographic:

a. contrast

b. unsharpness

c. reticulation

d. density

A.15.33

15. The difference between the densities of two areas of a radiograph is called:

a. radiographic contrast

b. subject contrast

c. film contrast

d. definition

F.67

16. The most widely used unit of measurement for measuring the rate at which the output of a gamma ray source decays is the:

a. curie

b. roentgen

c. half-life

d. MeV

A.13.12-13

17. Exposure to X-rays or gamma rays:

a. may have a cumulative effect which must be considered

b. will be beneficial since they build up an immunity to radiation poisoning

c. will have no effect on human beings

d. will have only a short-term effect on human tissues

A.26.3

18. Which dose would be dangerous, if not fatal, if applied to the entire body in a short period of time?

a. 1.5-15 R ($4\text{-}38 \times 10^{-4}$ C/kg)

b. 25-70 R

c. 200-800 R

d. all of the above doses would most likely be fatal

A.26.2

19. When doing gamma ray radiography with high-intensity emitters, the sources are best handled:

a. directly by personnel equipped with special protective clothing

b. by remote handling equipment

c. directly by personnel with special protective clothing except when radiographs are being made

d. by the same methods used for low-intensity emitters

A.15.22

20. If a film is placed in a developer solution and allowed to develop without any agitation:

a. the radiograph will not show proper contrast

b. it will be impossible to fix the radiograph permanently

c. there will be a general "fogging" condition over the entire radiograph

d. there will be a tendency for areas to affect each other

F.83

21. The selection of the proper type of film to be used for the X-ray examination of a particular part depends on:

a. the thickness of the part

b. the material of the specimen

c. the voltage range of the available X-ray machine

d. all of the above

F.75
- # Level III Answers

Radiographic Testing Method
1. b

2. b

3. a

4. d

5. c

6. c

7. a

8. b

9. c

10. c

11. a

12. d

13. a

14. b

15. a

16. c

17. a

18. b

19. a

20. b

21. d

22. c

23. b

24. c

25. a

26. c

27. d

28. c

29. a

30. a

31. b

32. c

33. b

34. d

35. c

36. b

37. a

38. d

39. b

40. c

41. b

42. a

43. b

44. b

45. d

46. b

47. a

48. c

49. b

50. a

51. b

52. a

53. c

54. d

55. c

56. c

57. b

58. d

59. c

60. c

61. b

62. d

63. c

64. b

65. b

66. d

67. b

68. b

69. a

70. c

71. a

72. a

73. b

74. d

75. d

76. d

77. c

78. b

79. c

80. a

81. c

82. b

83. c

84. c

85. a

86. d

87. d

88. c

89. a

90. a

91. c

92. a

93. a

94. a

95. b

96. b

97. d

98. c

99. c

100. c

101. d

102. d

103. c

104. a

105. b

106. b

107. d

108. c

109. c

110. b

111. b

112. b

113. d

114. c

115. d

116. b

117. a

118. b

119. c

120. d

121. b

122. b

123. a

124. d

125. b

126. b

127. d

128. b

129. c

130. b

131. a

132. a

133. d

134. d

135. a

136. d

137. b

138. c

139. c

140. b

141. c

142. d

143. d

144. c

145. c

146. b

147. a

148. c

149. b

150. d

151. b

152. c
- 8
- 69

274. Indications on a radiograph that appear as dark, ragged lines of variable widths and numerous branches with no definite line of continuity are indicative of:
- a. cold cracks
 - b. cold shuts
 - c. hot tears
 - d. core shifting
- G.147**
275. A dark line of varying width on a radiograph that follows the edge of the fusion zone of a weld is indicative of:
- a. undercutting
 - b. incomplete fusion
 - c. porosity
 - d. shrinkage
- G.148**
276. An indication appearing on a radiograph as a dark, elongated area of varying length or width located at the center of a weld would probably be classified as:
- a. aligned porosity
 - b. slag line
 - c. wagon tracks
 - d. lack of penetration
- E.7-36**
277. An oval or circular dark spot with smooth edges appearing on the radiograph would most probably be indicative of:
- a. burn through
 - b. crater crack
 - c. porosity
 - d. lack of fusion
- E.7-46**
278. An intermittent or continuous dark line found at the edge of the weld groove or bevel would probably be classified as:
- a. aligned porosity
 - b. slag line
 - c. root concavity
 - d. crater cracking
- A.25.4**
279. A narrow, dark line traveling in irregular directions would generally indicate the presence of:
- a. a crack
 - b. slag line
 - c. aligned porosity
 - d. lack of fusion
- A.25.8**
280. A very thin, straight, dark line, either continuous or intermittent, located parallel to and normally on one side of a weld would be indicative of:
- a. slag inclusion
 - b. suck-up
 - c. aligned porosity
 - d. lack of fusion
- D.127**
281. Indications appearing singly or as clusters of small, light spots in a GTA weld would most probably be classified as:
- a. weld spatter
 - b. nonmetallic inclusion
 - c. tungsten inclusion
 - d. gas holes
- D.127**
282. The term used to describe the reduction in the base metal thickness where the last weld bead is fused to the surface is called:
- a. convexity
 - b. undercut
 - c. lack of fusion
 - d. concavity
- B.136**
283. A term used to describe the oxides and other solids which are shown radiographically as elongated or rounded inclusions is:
- a. slag
 - b. porosity
 - c. suck-up
 - d. worm holes
- B.136**
28. In order to decrease geometric unsharpness:
- a. radiation should proceed from as small a focal spot as other considerations will allow
 - b. radiation should proceed from as large a focal spot as other considerations will allow
 - c. the film should be as far as possible from the object being radiographed
 - d. the distance from the anode to the material examined should be as small as is practical
- A.15.14**
23. X-ray tube current is controlled by:
- a. the current passing through the filament
 - b. the distance from the cathode to the anode
 - c. the type of material used in the target
 - d. the voltage and waveform applied to the X-ray tube
- A.14.6; F.9**
24. The voltage and waveform applied to the X-ray tube by a high-voltage transformer primarily determines the:
- a. quantity of radiation
 - b. duration of exposure
 - c. penetrating ability
 - d. X-ray beam divergence
- A.14.6**
25. Lead foil in direct contact with X-ray film:
- a. intensifies the scatter radiation more than the primary radiation
 - b. decreases the contrast of the radiographic image
 - c. intensifies the primary radiation more than the scatter radiation
 - d. should not be used when gamma rays are emitted by the source of radiation
- F.32**
26. Fluorescent intensifying screens are usually mounted in pairs in rigid holders called:
- a. film racks
 - b. cassettes
 - c. emulsifiers
 - d. diaphragms
- F.37**
27. Radiographic sensitivity, in the context of the minimum detectable flaw size, depends on:
- a. graininess of the film
 - b. the unsharpness of the flaw image in the film
 - c. the contrast of the flaw image on the film
 - d. all of the above
- A.15.32**
30. In order to increase the intensity of X-radiation:
- a. the tube current should be increased
 - b. the tube current should be decreased
 - c. the test specimen should be moved farther from the film
 - d. a lower kilovoltage should be applied to the tube
- A.20.3; F.9**
31. Primary radiation which strikes a film holder or cassette through a thin portion of the specimen will cause scattering into the shadows of the adjacent thicker portions producing an effect called:
- a. radiation imaging
 - b. spotting
 - c. undercut
 - d. unsharpness
- A.20.19; F.39**
32. Scattered radiation caused by any material, such as a wall or floor, on the film side of the specimen is referred to as:
- a. primary scattering
 - b. undercut
 - c. reflected scattering
 - d. backscattered radiation
- F.39-40**
33. Which of the following materials is suitable for use in vessels or pails and used to mix processing solutions?
- a. stainless steel
 - b. aluminum
 - c. galvanized iron
 - d. tin
- A.21.2**

Radiographic Testing Method, Level I

34. Of the following, which would be especially sensitive to injury by excessive exposure to X- or gamma rays?
- a. blood
 - b. lens of the eye
 - c. internal organs
 - d. all of the above
- F.142**
35. X-ray exposure may be due to:
- a. the direct beam from the X-ray tube target
 - b. scatter radiation arising from objects in the direct beam
 - c. both a and b
 - d. both a and b plus residual radiation that exists for the first few minutes after the X-ray machine has been returned to the "off" position
- F.142**
36. A general rule often employed for determining the kilovoltage to be used when X-raying a part is that:
- a. the kilovoltage should be as high as other factors will permit
 - b. the kilovoltage should be as low as other factors will permit
 - c. the kilovoltage is always a fixed value and cannot be changed
 - d. the kilovoltage is not an important variable and can be changed over a wide range without affecting the radiograph
- F.29**
37. If a piece of lead 13 mm (0.5 in.) thick is placed in the path of a beam of radiation emanating from Co-60, it will reduce the dose rate at a given location by:
- a. one-third
 - b. one-quarter
 - c. one-half
 - d. three-quarters
- A.26.9**
38. Excessive exposure of film to light prior to development of the film will most likely result in:
- a. a foggy film
 - b. poor definition
 - c. streaks
 - d. yellow stain
- F.148**
39. Reticulation resulting in a puckered or net-like film surface is probably caused by:
- a. crimping film after exposure
 - b. sudden extreme temperature change while processing
 - c. water or developer on unprocessed film
 - d. excessive object-to-film distance
- F.150**
40. Filling or loosening of the emulsion from the base of the film is most likely caused by:
- a. water or developer on unprocessed film
 - b. low temperature of processing solutions
 - c. developer solution contamination
 - d. warm or exhausted fixer solution
- F.151**
41. If an exposure time of 60 seconds was necessary using a 1.2 m (4 ft) source-to-film distance for a particular exposure, what time would be necessary if a 0.6 m (2 ft) source-to-film distance is used and all other variables remain the same?
- a. 120 s
 - b. 30 s
 - c. 15 s
 - d. 240 s
- F.47**
42. One of the general rules concerning the application of geometric principles of shadow formation to radiography is:
- a. the X-rays should proceed from as large a focal spot as other considerations will allow
 - b. the film should be as far as possible from the object being radiographed
 - c. the distance between the anode and the material examined should always be as great as possible
 - d. all of the above
- F.20**
43. As a check on the adequacy of the radiographic technique, it is customary to place a standard test piece on the source side of the specimen. This standard test piece is called a:
- a. reference plate
 - b. lead screen
 - c. penetrometer
 - d. illuminator
- A.20.36; F.69**
44. The duration of an exposure is usually controlled by:
- a. controlling the milliamperage
 - b. a timer
 - c. controlling the source-to-film distance
 - d. a choke coil in the filament transformer
- A.14.6**
45. A penetrometer is used to indicate the:
- a. size of discontinuities in a part
 - b. density of the film
 - c. amount of film contrast
 - d. quality of the radiographic technique
- F.73**

10

Radiographic Testing Method, Level III

262. A discontinuity consisting of one or several parallel fissures caused by the internal rupture or fracture of material while in the hot semiplastic state is called:
- a. lack of fusion
 - b. tear
 - c. unfused chaplet
 - d. hot crack
- B.140**
263. Cracks or fractures formed in a casting prior to completion of solidification because of restricted contraction is indicative of a:
- a. shrinkage cavity
 - b. hot tear
 - c. misrun
 - d. cold shut
- G.309**
264. A discontinuity that may be the result of improper pouring temperature or alloy composition is indicative of:
- a. gas porosity
 - b. shrinkage porosity
 - c. dispersed discontinuities
 - d. unfused chaplets
- G.147**
265. A discontinuity caused by gas released during solidification or by the evaporation of moisture or volatile material from the mold surface is indicative of:
- a. microshrinkage
 - b. shrinkage porosity
 - c. an inclusion
 - d. gas porosity
- G.147**
266. Failure of the metal to fill the mold cavity, thus creating a casting that is not complete, is:
- a. a core shift
 - b. a cold shut
 - c. a misrun
 - d. buckles
- G.309**
267. A definite discontinuity that exists because of imperfect fusion of two streams of metal that have converged is:
- a. a misrun
 - b. a cold shut
 - c. raitails
 - d. buckles
- E.7-10; G.309**
268. Voids in a casting caused by inadequate feeding to compensate for the volumetric shrinkage that occurs during solidification are:
- a. shrinkage cavities
 - b. shifts
 - c. hot tears
 - d. blowholes
- C.309**
269. Particles of foreign material such as sand or slag that are embedded in the cast metal are:
- a. gas holes
 - b. buckles
 - c. rattails
 - d. inclusions
- G.309**
- Radiographic Appearance of Discontinuities**
270. An indication on a casting radiograph that appears as distinct dark lines or a band of variable length and width, with a definite smooth outline, is indicative of:
- a. shrinkage
 - b. segregation
 - c. cold shuts
 - d. tears
- G.147**
271. Voids that are readily recognizable as smooth, dark, round or oval-shaped spots with radiographic contrast varying directly with their diameter are:
- a. gas porosity
 - b. shrinkage porosity
 - c. segregation
 - d. core shifting
- G.147**
272. An uneven wall thickness in an internal passage of a casting as viewed in a radiograph is indicative of:
- a. misruns
 - b. segregation
 - c. unfused chaplets
 - d. core shifting
- G.148**
273. If an elongated dark area of varying length and width that is either continuous or intermittent appears in the center of a radiograph of a weldment, it is indicative of:
- a. cracks
 - b. incomplete penetration
 - c. inclusions
 - d. shrinkage
- G.148**

67

252. Of the following, which gaging application is most suitable for using gamma rays?
- a. cigarette density gaging
 - b. thickness gaging of thin foils such as condenser papers
 - c. paper thickness gage
 - d. liquid density gage
- A.20.21

Real-time Imaging

253. In a system using a high-resolution screen and low-light level TV, real-time imaging must be conducted on 13 mm (0.5 in.) steel at 20 fpm. The motion unsharpness must be held to 0.2 mm (0.008 in.). Source-to-object distance = 41 cm (16 in.) and focal spot is 0.7 mm (0.03 in.). Using the formula $U = wt/L_o$, determine the width of the radiation beam in the direction of motion.

- a. 16 cm (6.4 in.)
- b. 81 mm (3.2 in.)
- c. 63 mm (2.5 in.)
- d. 25 mm (1 in.)

G.138

254. In comparing electronic image intensifier systems that use TV presentation with those using solid-state screens and high-sensitivity closed-circuit TV systems, which of the following statements is false?

- a. the overall gain of an image intensifier/TV combination usually exceeds that of the screen/TV combinations
- b. the overall resolution of the intensifier/TV combination usually exceeds that of the screen/TV combination
- c. as the area of the viewed screen increases for either, the overall system gain must also increase
- d. the single crystal scintillating screens and the fine-grain fluorescent screens have better resolution than the electronic image intensifier tubes but much lower light output

A.19.39

Image-Object Relationships

255. Using geometric enlargement principles, determine the image size if the object is 15 cm (6 in.) in diameter, the source-to-film distance is 91 cm (36 in.), and the source-to-object distance is 76 cm (30 in.).
- a. 18 cm (7.2 in.)
 - b. 13 cm (5 in.)
 - c. 37 cm (14.4 in.)
 - d. 25 cm (10 in.)
- F.19

256. The focal spot should be as small as possible, because there is a definite relationship between the focal spot size and:
- a. radiographic contrast
 - b. total radiation output
 - c. subject contrast
 - d. radiographic definition
- F.21

257. Which of the following influences the amount of radiation that falls on the recording plane in the umbral region of the image?

- a. the thickness characteristics of the test specimen
- b. the angle of the incident radiation
- c. the size of the recording plane
- d. the thickness of the recording plane

G.131

Material Processing

258. A consequence of insufficient heat or the presence of scale on the fusion face of the weld bevel may be:
- a. incomplete penetration
 - b. root concavity
 - c. excessive root reinforcement
 - d. lack of fusion
- A.25.9

259. A weld made with an excessive number of passes or inadequate speed of travel could result in:

- a. root concavity
- b. oxidation
- c. excessive root reinforcement
- d. incomplete penetration

A.20.21

Discontinuities: Their Causes and Effects

260. Steels that contain more than 0.30 percent carbon if welded are prone to which type of discontinuity?

- a. heat-affected zone cracking
- b. porosity
- c. lack of fusion
- d. slag formation

E.7-18

261. A discontinuity in welds caused by gas entrapment in the molten metal, moisture, improper cleaning, or lack of preheat is called:

- a. dross
- b. lack of penetration
- c. porosity
- d. slag inclusion

E.7-46

46. A fluorescent intensifying screen will:
- a. transform X-ray energy into visible or ultraviolet light
 - b. result in reticulation
 - c. decrease the graininess of the image when using gamma rays
 - d. increase the definition in a radiograph
- A.16.16
52. When manually processing films, the purpose for sharply tapping hangers two or three times after the films have been lowered into the developer is to:
- a. disperse unexposed silver grains on the film surface
 - b. prevent frilling
 - c. dislodge any air bubbles clinging to emulsion
 - d. do all of the above
- A.21.5

47. The three main steps in processing a radiograph are:

- a. developing, frilling, and fixation
 - b. developing, fixation, and washing
 - c. exposure, developing, and fixation
 - d. developing, reticulating, and fixation
- A.16.18

48. Kilovoltage, exposure time, and source-to-film distance are three of the most important X-ray exposure factors that can be controlled. A fourth such exposure factor is:

- a. focal point size
 - b. temperature
 - c. filament-to-focal spot distance
 - d. milliamperage
- A.20.15

49. When the minute silver grains on which the X-ray film image is formed group together in relatively large masses, they produce a visual impression called:

- a. air bells
 - b. graininess
 - c. reticulation
 - d. frilling
- F.132

50. Static marks, which are black tree-like or circular marks on a radiograph, are often caused by:

- a. film being bent when inserted in a cassette or holder
 - b. foreign material or dirt imbedded in screens
 - c. scratches on lead foil screens
 - d. improper film handling techniques
- F.148

51. The purpose of agitating an X-ray film during development is to:

- a. protect the film from excessive pressure
 - b. renew the developer at the surface of the film
 - c. disperse unexposed silver grains on the film surface
 - d. prevent reticulation
- A.21.5

54. The purpose of fixation is:

- a. to remove all the undeveloped silver salts of the emulsion
 - b. to leave the developed silver as a permanent image
 - c. to harden the gelatin
 - d. all of the above
- A.21.7

55. For best results when manually processing film, solutions should be maintained within a temperature range of:

- a. 18 to 24 °C (65 to 75 °F)
 - b. 65 to 75 °C (149 to 167 °F)
 - c. 24 to 29 °C (75 to 85 °F)
 - d. 75 to 85 °C (167 to 185 °F)
- A.21.4-5

56. Water spots on films can be minimized by:

- a. the rapid drying of wet film
 - b. using a wetting agent solution
 - c. using a fresh fixer solution
 - d. cascading water during the rinse cycle
- A.21.9

57. The small area in the X-ray tube from which the radiation emanates is called the:

- a. diaphragm
 - b. focal spot
 - c. focusing cup
 - d. cathode
- F.9-10

58. The radiation quality of a gamma ray source is:

a. determined by the size of the focal spot

b. determined by the isotope involved

c. varied by the operator

d. greater in Ir-192 than in Co-60

F.14
59. The most common material used to provide protection against X-rays is:

a. high-density brick

b. an alloy of 70 percent steel and 30 percent copper

c. tungsten

d. lead

F.143
60. A curie is the equivalent of:

a. 0.001 mCi

b. 1 000 mCi

c. 1 000 MCi

d. 100 MCi

D.22
61. With a given exposure time and kilovoltage, a properly exposed radiograph is obtained with a 6 mA-minutes exposure at the distance of 51 cm (20 in.). It is desired to increase the sharpness of detail in the image by increasing the source-to-film distance to 102 cm (40 in.). The correct milliamperage-minutes exposure to obtain the desired radiographic density at the increased distance is:

a. 12 mA-minutes

b. 24 mA-minutes

c. 3 mA-minutes

d. 1.7 mA-minutes

F.47
62. Very short wavelength electromagnetic radiation produced when electrons travelling at high speeds collide with matter is called:

a. X-radiation

b. beta radiation

c. gamma radiation

d. none of the above

F.9
63. The exposure of personnel to X- and gamma radiation can be measured or monitored by means of:

a. film badges

b. dosimeters

c. radiation exposure survey meters

d. all of the above

B.204
64. Assuming that a good radiograph is obtained at a setting of 10 mA in 40 s, how much time will be necessary to obtain one equivalent radiograph if the milliamperage is changed to 5 mA (all other conditions remaining constant)?

a. 20 s

b. 10 s

c. 80 s

d. 160 s

F.47
65. A graph showing the relation between material thickness, kilovoltage, and exposure is called:

a. a bar chart

b. an exposure chart

c. a characteristic curve

d. an H&D curve

F.51
66. A graph which expresses the relationship between the logarithm of the exposure applied to a photographic material and the resulting photographic density is called:

a. a bar chart

b. an exposure chart

c. the characteristic curve

d. a logarithmic chart

F.53
67. Short wavelength electromagnetic radiation produced during the disintegration of nuclei of radioactive substances is called:

a. X-radiation

b. gamma radiation

c. scatter radiation

d. backscatter radiation

F.14
68. A photographic image recorded by the passage of X- or gamma rays through a specimen onto a film is called a:

a. fluoroscopic image

b. radiograph

c. isotopic reproduction

d. none of the above

A.20.1
69. The normal development time for manually processing X-ray film is:

a. 12-18 minutes in processing solutions at 24 °C (75 °F)

b. 3-8 minutes in processing solutions at 16 °C (60 °F)

c. 12-18 minutes in processing solutions at 68 °C (154 °F)

d. 5-8 minutes in processing solutions at 20 °C (68 °F)

A.21.4

Electron Emission Radiography

242. Electron radiography is primarily used for radiography of:

a. high atomic number (Z) materials

b. thin metallic specimens

c. very thin nonmetallic specimens

d. combination of high and low atomic number materials

F.119
243. An electron emission radiograph shows surface details only; in this regard, it is similar to:

a. a macroradiograph

b. a microradiograph

c. a photomicrograph

d. tomography

F.120
244. The principle of electron emission radiography is based on:

a. differential absorption

b. diffraction caused by crystalline structure

c. differences in electron emission from an irradiated specimen, resulting from greater emission from higher atomic number materials

d. differences in film density caused by the differential penetrating ability of the various energy electrons

F.120
245. Which one of the following is not a commonly accepted use of microradiography?

a. determination of segregation of constituents in thin alloy sections

b. detection of minute discontinuities

c. study of biological sections

d. study crystalline structure

F.116
246. X-ray devices used in microradiography typically operate at potentials up to:

a. 50 kV

b. 100 kV

c. 150 kV

d. 200 kV

F.116

Control of Diffraction Effects

247. Filters and screens are devices used by radiographers to control diffraction effects. If spurious indications appear in the finished radiograph and diffraction is suspect, what technique aids or corrections can be made to the technique to *eliminate* suspect diffraction patterns?

a. raise the kilovoltage

b. lower the kilovoltage

c. change the radiation center 127 mm (5 in.) from the previous location

d. change the class and type of film used from type 1 to type 2

F.39
248. X-ray diffraction patterns appearing in a radiograph are typically observed in the radiography of:

a. thick castings at greater than 1 MeV

b. thin metallic specimens with large grain size

c. thin metallic specimens with fine grain size

d. thick metallic specimens with low atomic number (Z)

A.20.24
249. The radiographic appearance of diffraction patterns is mottled and may be confused with which one of the following sets of indications?

a. porosity or segregation

b. oxidation or burn through

c. porosity or burst

d. misruns or porosity

A.20.24
250. A method for distinguishing between diffraction mottling and other causes of mottling is to:

a. reexpose the film using a much lower exposure factor

b. change the angle of incidence of the beam by 1-5 degrees and reexpose

c. lower the kilovoltage and reexpose

d. reexpose without using lead screens

A.20.24
251. In routine thickness gaging setups using gamma ray sources, which one of the following radiation detectors is most commonly used?

a. anthracene crystal

b. ionization chamber

c. sodium iodide crystal

d. Geiger-Müller tube

A.20.21

Gaging

233. If the thickness range of a specimen is too great for a single exposure, a multifilm technique may be used. If two films of different speeds are selected for this example, the log relative exposure range for these two films is:

- a. the difference in log exposure between the value at the high-density end of the faster film and the low-density end of the slower film curve
- b. the difference in log exposure between the value at the low-density end of the faster film and the high density end of the slower film
- c. the difference in log exposure between the value at the low-density end of the slower film and the high-density end of the faster film
- d. the difference in log exposure between the value at the high-density end of the slower film and the low-density end of the faster film

F.39

Stereoradiography

234. Select the one advantage stereoradiographs have over films produced by parallax method.

- a. they permit correct spatial relation
- b. they use inexpensive viewing devices
- c. they require special reading glasses
- d. they use two films

A.20.21

235. A setup by which an arrangement of prisms or mirrors permits each eye to see but a single one of a pair of radiographs is known as:

- a. stroboradiography
- b. parallax radiography
- c. stereoradiography
- d. autoradiography

F.106

Triangulation Methods

236. Using the parallax method for triangulation with the film in contact with the object and shifting the source equal distance in two directions from its original position for location of a flaw, it is revealed that the flaw shift is less than half the shift of the source side marker. The flaw is:

- a. nearer the film plane
- b. nearer the source side
- c. on the source-side surface
- d. on the film-side surface

F.108

237. A discontinuity was found by radiography in a 76 mm (3 in.) thick weld. The source-to-film distance was 51 cm (20 in.). A second exposure was made with the source shifted 102 mm (4 in.) parallel to the film plane. It was noted that the discontinuity image moved 16 mm (0.625 in.) as compared with the original exposure. Determine the distance of the flaw above the film.

- a. 82 mm (3.24 in.)
- b. 32 mm (1.25 in.)
- c. 69 mm (2.70 in.)
- d. 7 mm (0.27 in.)

F.107

Flash Radiography

238. Radiography performed using high-intensity X-ray beams with microsecond exposures is:

- a. microradiography
- b. autoradiography
- c. stroboradiography
- d. flash radiography

F.12; H.238

Fluoroscopy

239. The optimum magnification to obtain optimum image clarity in a dynamic fluoroscopic system is determined using the equation $M_o = 1 + (U/F)^{3/2}$. For a system with a screen unsharpness of 0.5 mm (0.02 in.) and a 0.7 mm (0.03 in.) focal spot, determine the optimum geometric magnification.

- a. 2.0
- b. 1.6
- c. 1.06
- d. 2.6

G.150

240. One of the main disadvantages of fluoroscopic systems is the:

- a. extensive operator training required
- b. high image brightness on screen
- c. flaw image enlargement
- d. limited ability to see fine detail

G.149

241. Which one of the following is not a common method of viewing a fluoroscopic image?

- a. through a phosphor-coated lead glass screen
- b. mirror projection of the image
- c. using of an imaging orthicon
- d. through a calcium tungstate screen

G.150

75. An advantage of the pocket dosimeter type of ionization chamber used to monitor radiation received by personnel is:

- a. it provides a permanent record of accumulated dosage
- b. it provides an immediate indication of dosage
- c. it is the most sensitive detector available
- d. all of the above are advantages

A.26.4; D.41

76. The density difference between two selected portions of a radiograph is known as:

- a. unsharpness
- b. radiographic contrast
- c. specific activity
- d. subject density

A.15.35; 20.24; F.67

77. One requirement for keeping fluorescent screens in good condition is that they must:

- a. be cleaned with a lint-free cloth each time they are used
- b. not be exposed to intense ultraviolet radiation
- c. be mounted in a rigid container at all times
- d. not be exposed to caustic fumes

A.16.15

78. In making an isotope exposure in an unshielded area, you find the dose rate 1.8 m (6 ft) from the source is 1 200 mR/h. What would be the dose rate at 7.3 m (24 ft)?

- a. 75 mR/h
- b. 100 mR/h
- c. 200 mR/h
- d. 300 mR/h

A.15.6

79. The intensity of X- or gamma radiation is measured in:

- a. roentgens
- b. ergs
- c. roentgens per unit of time
- d. H&D units

A.15.5; D.28

80. When producing radiographs, if the kilovoltage is increased, the:

- a. subject contrast decreases
- b. film contrast decreases
- c. subject contrast increases
- d. film contrast increases

A.20.35

70. In order to achieve uniformity of development over the area of an X-ray film during manual processing:

- a. the film should be placed in a dryer after being developed
- b. the developer should be agitated by using mechanical stirrers or circulating pumps
- c. the film should be agitated while in the developer
- d. the film should be transferred directly from the developer to the fixer

A.21.5

71. When referring to a "2T" or "4T" hole in the ASTM penetrometer, the T refers to the:

- a. part thickness
- b. penetrometer thickness
- c. time of exposure
- d. time for developing

A.20.37

72. A sheet of lead with an opening cut in the shape of the part to be radiographed may be used to decrease the effect of scattered radiation which undercuts the specimens. Such a device is called a:

- a. mask
- b. filter
- c. backscatter absorber
- d. lead foil screen

F.40

73. Two X-ray machines operating at the same nominal kilovoltage and milliamperage settings:

- a. will produce the same intensities and qualities of radiation
- b. will produce the same intensities but may produce different qualities of radiation
- c. will produce the same qualities but may produce different intensities of radiation
- d. may give not only different intensities but also different qualities of radiation

D.106

74. Fluoroscopy differs from radiography in that:

- a. fluoroscopy uses a much lower kilovoltage than radiography
- b. fluoroscopy is much more sensitive than radiography
- c. the X-ray image is observed visually on a fluorescent screen rather than recorded on a film
- d. fluoroscopy permits examination of thicker parts than does radiography

F.113

81. The accidental movement of the specimen or film during exposure or the use of a focus-film distance that is too small will:

a. produce a radiograph with poor contrast

b. make it impossible to detect large discontinuities

c. result in unsharpness of the radiograph

d. result in a fogged radiograph

A.15.33
82. A properly exposed radiograph that is developed in a developer solution at a temperature of 14 °C (58 °F) for 5 minutes will probably be:

a. overdeveloped

b. underdeveloped

c. fogged

d. damaged by frittling

A.21.4
83. A good radiograph is obtained using a milliamperage of 15 mA and an exposure time of 0.5 minutes. What exposure time will be necessary to produce an equivalent radiograph if the milliamperage is changed to milliamperes and all other conditions remain the same?

a. 4.5 minutes

b. 1.5 minutes

c. 3 minutes

d. 0.5 minutes

A.20.13
84. Lead screens in contact with the film during exposure:

a. increase the photographic action on the film largely by reason of the electron emission and partly by the secondary X-rays generated in the lead

b. absorb the shorter wavelength scattered radiation more than the long wavelength primary radiation

c. intensify the photographic effect of the scatter radiation more than that of the primary radiation

d. none of the above

A.20.25
85. The sharpness of the outline in the image of the radiograph is a measure of:

a. subject contrast

b. radiographic definition

c. radiographic contrast

d. film contrast

A.20.35
86. An unshielded isotope source gives a dosage rate of 900 mR/h at 3 m (10 ft). What would the unshielded dosage rate be at 9 m (30 ft)?

a. 300 mR/hr

b. 600 mR/hr

c. 100 mR/hr

d. 2 700 mR/hr

A.15.6
87. Which has the shortest wavelengths?

a. visible light

b. microwaves

c. 100 kV peak X-rays

d. infrared radiation

A.13.9; F.7
88. Beta particles are:

a. neutrons

b. protons

c. electrons

d. positrons

A.13.1
89. A radioactive source with an activity of 1 Ci has:

a. 1 000 disintegrations per second taking place

b. 1 000 000 disintegrations per second taking place

c. 1 000 000 000 disintegrations per second taking place

d. 3.7×10^{10} disintegrations per second taking place

A.13.13
90. The formula for determining permissible accumulated personnel dose is:

a. $12 (N - 18)$

b. $18 (5 + N)$

c. $5 (N - 18)$

d. $12 (N + 18)$

D.56
91. The metal that forms the image on an X-ray film is:

a. tin

b. silver

c. tungsten

d. iron

F.135
92. Unexposed boxes of X-ray film should be stored:

a. flat

b. on edge or end

c. in a pile

d. it does not matter

F.79

Exposure Calculations

223. If an exposure time of 1 minute was necessary using a 1.8 m (6 ft) source-to-film distance for a particular exposure, what time would be necessary if a 0.9 m (3 ft) source-to-film distance is used and all other variables remain the same?

a. 2 minutes

b. 15 s

c. 4 minutes

d. 30 s

F.39
224. The mathematical rule of exposure which governs the *time-distance relation* of the basic exposure calculator is:

a. the exposure time (*T*) required for a given exposure is directly proportional to the square of the source-to-film distance (*D*)

b. the exposure time (*T*) required for a given exposure is inversely proportional to the square of the source-to-film distance (*D*)

c. the exposure time (*T*) required for a given exposure is inversely proportional to the milliamperage (*M*)

d. none of the above

F.39
225. Assume that a radioisotope source has an emission rate of 0.6 µC/kg/h/Bq (6 mR/h/mCi) at 0.30 m (1 ft). If a 30 GBq (800 mCi) source is used, determine the dosage rate at 0.60 m (2 ft).

a. 124C/kg/h (4800 mR/h)

b. 310 µC/kg/h (1200 mR/h)

c. 138 µC/kg/h (533 mR/h)

d. 77 µC/kg/h (300 mR/h)

D.29
226. The primary function of a filter is to:

a. reduce the penetrating ability of the radiation

b. absorb longer wavelengths, which can produce increased scatter

c. reduce exposure time

d. eliminate most of the undercut caused by scatter

A.20.22; F.39
227. Which of the following materials are typically used for filtration purposes in industrial radiography at energies of 150–400 kV?

a. aluminum/magnesium

b. lead/copper

c. stainless steel/steel

d. cadmium/zinc

F.39

228. A filter in the X-ray tube beam has the effect of:

a. hardening the radiation beam

b. softening the radiation beam

c. dispersing the radiation beam

d. increasing the beam intensity

F.39
229. Scattered radiation originating in matter outside the specimen is most serious for specimens which have high absorption for X-rays. One of the most satisfactory arrangements for combining effectiveness and convenience to reduce scatter when radiographing steel is to:

a. cut out diaphragms from lead sheet

b. pack barium clay around the specimen

c. use a liquid absorber

d. surround the object with copper or steel shot

A.20.21
230. Filtering an X-ray beam is analogous to:

a. decreasing the kilovoltage

b. increasing the kilovoltage

c. decreasing the milliamperage

d. increasing the milliamperage

F.39
231. The primary purpose of using two or more films of unequal speed in the same cassette is to:

a. eliminate retakes due to incorrect exposure time

b. eliminate retakes due to artifacts on the film

c. cover a wide range of thickness in one exposure

d. reduce the scatter to the total image

B.133
232. When two different films are selected for a multiframe technique, their speeds must be such that on their characteristic curves:

a. there is some overlap on the density axis

b. there is no overlap on the density axis

c. there is some overlap on the log *E* axis

d. there is no overlap on the log *E* axis

F.39

Multifilm Techniques

231. The primary purpose of using two or more films of unequal speed in the same cassette is to:

213. Prolonged washing of film in water above 20 °C (68 °F) has a tendency to:

- a. crystallize the gelatin
- b. soften the gelatin
- c. cause yellow stain
- d. cause the image to fade

F.39

214. When using lead foil intensifying screens, a fuzzy radiographic image is a sign:

- a. of oil or grease on the screens
- b. that tin coating was used on the screens
- c. of poor screen-to-film contact
- d. of foreign material between the screen and the film

F.39

215. A mottled radiograph can be caused by:

- a. not removing the paper interleaving before the exposure
- b. using tin-coated lead screens
- c. X-ray diffraction effects
- d. all of the above

F.33, 44

Image Quality Indicators

Given $\alpha = \frac{100}{x} \sqrt{Th / 2}$ where

- x = material thickness (inches)
- T = penetrometer thickness (inches)
- h = essential hole diameter (inches)
- a = equivalent sensitivity (percent)

216. Using the formula given above, calculate the equivalent sensitivity of an ASTM #20 penetrometer showing the 2T hole on a 32 mm (1.25 in.) thick specimen.

- a. 2.0 percent
- b. 1.6 percent
- c. 18 percent
- d. 1.4 percent

C.E142

217. Using the formula given above, calculate the specimen thickness if the equivalent sensitivity is 2.6 percent based on seeing the 4T hole in an ASTM #40 penetrometer.

- a. 34 mm (1.35 in.)
- b. 80 mm (3.17 in.)
- c. 65 mm (2.56 in.)
- d. 55 mm (2.17 in.)

C.E142

218. The DIN type penetrometer is which type of image quality indicator?

- a. a plaque type
- b. a stepped type
- c. a wire type
- d. an indirect imaging type

F.39

Causes and Correction of Unsatisfactory Radiographs

219. Omission of the stop bath or rinsing of the film may cause:

- a. streaking of the film
- b. yellow staining of the film
- c. fogging of the film
- d. frilling of the emulsion

F.150

220. In automatic processing, poor drying of film can be attributed to which of the following if the drying temperature and air circulation in the drying section are found to be acceptable?

- a. underreplenishment of the fixer solution
- b. infrequent use of the processor
- c. roller alignment in the wash section
- d. overdevelopment

F.152

221. In automatic processing, streaks on the film can be attributed to:

- a. a long interval between feeding of films
- b. clogged developer recirculation system
- c. dirty dryer tubes
- d. all of the above

F.152

222. A milky appearing fixer solution could be caused by:

- a. the fixer being too warm or exhausted
- b. a sudden change in temperature
- c. use of a carbonate developer
- d. use of fine-grained film

F.150

99. A thin metallic sheet (brass, copper, aluminum, etc.) placed at the source to reduce effects of softer radiation is known as:

- a. an intensifying screen
- b. a filter
- c. an electron inducer
- d. a focusing cup

B.118; E.6-7; F.42

100. The reason a “shim” is used in radiographic setup is to:

- a. improve the penetrometer image
- b. reduce diffraction
- c. simulate weld reinforcement
- d. intensify the image

E.6-13; G.140

101. The focal spot size of an X-ray machine must be known in order to determine the:

- a. geometric unsharpness value
- b. kilovolt peak output
- c. milliamperage settings
- d. exposure time

E.3-6; F.21

102. A section with a significant increase in thickness variation is required to be shown on a single radiograph within a desired film density range. This may be accomplished by:

- a. increasing kilovoltage
- b. using a coarser grain film
- c. both a and b
- d. neither a nor b

F.30

103. The density of a radiograph image refers to the:

- a. thickness of the film
- b. thickness of the specimen
- c. weight of the film
- d. degree of film blackening

A.20.3; F.51

104. A beam of radiation consisting of a single wavelength is known as:

- a. characteristic radiation
- b. fluoroscopic radiation
- c. monochromatic radiation
- d. microscopic radiation

A.13.9

Radiographic Testing Method, Level I

105. The image of the required penetrometer and hole on the radiograph indicates that the radiograph has the required:

- a. contrast
- b. definition
- c. sensitivity
- d. latitude

E-6-10; F-69

106. The primary parts of an atom are:

- a. proton, neutrino, electron
- b. proton, electron, gamma ray
- c. photon, electron, neutron
- d. proton, electron, neutron

E-2-13

107. X-rays and gamma rays always travel in:

- a. pairs
- b. orbital spheres
- c. straight lines
- d. none of the above

E-2-7

108. A large source size can be compensated for by:

- a. increasing the source-to-specimen distance
- b. addition of lead screens
- c. increasing the specimen-to-film distance
- d. increasing penumbra

E-6-25

109. Radiation arising directly from the target of an X-ray tube or an accelerator, or from a radioactive source, is usually referred to as:

- a. secondary radiation
- b. primary radiation
- c. backscatter
- d. inherent radiation

A-13-29

110. The extent to which X-rays can be successfully utilized in nondestructive testing is largely dependent upon:

- a. the intensity of the X-rays generated
- b. their wavelengths
- c. the dimensions of the area from which they are emitted
- d. the duration of their emission
- e. all of the above

A-14-1

111. To produce X-rays, electrons are accelerated to a high velocity by an electrical field and then suddenly stopped by a collision with a solid body. This body is called a:

- a. cathode
- b. filament
- c. target
- d. generator

112. The best X-ray efficiency is produced when the target material has a:

- a. low atomic number
- b. high atomic number
- c. low hardness
- d. high hardness

A-14-3

113. What is sometimes used to change the alternating current from the high voltage transformer to direct current for the purpose of increasing the X-ray machine output?

- a. rectifier
- b. cathode X-ray tubes
- c. gas X-ray tube
- d. vacuum X-ray tube

A-14-6

114. In X-radiography, the ability to penetrate the test object is governed by:

- a. source-to-film distance
- b. time
- c. kilovoltage
- d. milliamperage

F-24

115. Which of the following types of radiation is emitted by Co-60 and used in nondestructive testing?

- a. neutrons
- b. gamma rays
- c. X-rays
- d. alpha particles

F-14

116. The term used to describe the loss of excess energy by the nucleus of radioactive atoms is called:

- a. decay (disintegration)
- b. ionization
- c. scintillation
- d. activation

A-15-1; D-22

202. As the kilovoltage is increased, the subject contrast:

- a. increases
- b. decreases
- c. remains the same
- d. increases directly with E^2

A-20-35

203. Radiographic image quality may be adversely affected by poor subject contrast; this may be caused by:

- a. insufficient absorption differences in the specimen
- b. excessive radiation energy for the application
- c. scatter
- d. all of the above

F-66

204. The film contrast for the specimens being radiographed may be determined from:

- a. the size of film
- b. the radiation quality
- c. the slope of the characteristic curve for the film
- d. all of the above

F-67

205. Which of the following is independent, for most practical purposes, of the wavelength and distribution of the radiation reaching the film?

- a. subject contrast
- b. radiographic contrast
- c. film contrast
- d. definition

F-67

Definition

206. By increasing the source-to-film distance in a given exposure, the image sharpness is:

- a. increased
- b. decreased
- c. not affected
- d. decreased by a negligible amount

A-20-21; F-19-20

207. What is the effect of the sensitivity of a radiograph when the physical size of a gamma source is increased without changing any other exposure factors?

- a. sensitivity and geometric unsharpness are increased
- b. geometric sharpness and definition are increased
- c. physical source size does not affect sensitivity
- d. geometric sharpness is increased and sensitivity is decreased

A-20-7; F-19-20

208. The image sharpness of an object may be affected by:

- a. type of film
- b. type of screen
- c. radiation quality
- d. all of the above

F-66

209. When a lead screen radiograph of an object shows a poorly defined image of the object, one course of action to correct this may be to:

- a. change to a coarse-grain film
- b. use an X-ray tube of larger focal spot
- c. increase source-to-film distance
- d. change to fluorescent screens

F-148

Artifacts

210. During the loading of a film cassette, the lead foil screens are scratched. The resulting radiograph would show:

- a. no change since deep scratches are not related to the film
- b. broad fuzzy light lines corresponding to the scratches
- c. defined dark lines corresponding to deep scratches
- d. random film indication due to scatter caused by scratches

F-39

211. Deep scratches in lead screens result in dark lines on the radiograph. These are due to:

- a. loss of absorbing characteristic of the lead foil resulting in more of the X-ray source reaching the film
- b. the scratch resulting in a greater surface area of lead, causing a larger electron emission area which affects exposure of the film
- c. air gap between the deep scratch and film
- d. none of the above

F-39 (Fig. 27)

212. The appearance of colored stains on a processed radiograph could be caused by:

- a. neutralization of the acid in the fixer solution
- b. neutralization of the alkaline content in the fixer solution
- c. acidification of the fixer solution
- d. underdevelopment

F-39

Radiographic Testing Method, Level III

193. When viewing radiographs, the film viewer should provide light of an intensity that is evenly distributed with an adjustment to vary the intensity. In addition, the film viewer should have:

- a. a viewing surface at a 90-degree angle
- b. fresh bulbs
- c. a diffusing medium
- d. a light green color

A.25.2

194. To prevent damage to films, which of the following should be provided when viewing radiographs?

- a. masks or screens
- b. foot switch
- c. heat filter
- d. opal glass

A.25.2

Background Lighting

195. The contrast sensitivity of the human eye is greatest when the surroundings compared to the area of interest on a radiograph have:

- a. about the same brightness
- b. a lower brightness
- c. a higher brightness
- d. brightness is not a factor in contrast sensitivity

A.20.21

196. For best contrast sensitivity, the film viewing room should have lighting:

- a. as dark as possible
- b. approximately 38 lm
- c. approximately 70 lm
- d. as light as the area of interest in the film being reviewed

C.E94; F.73

197. When reviewing film, background lighting should:

- a. be virtually eliminated
- b. not reflect on the film under examination
- c. be carefully filtered
- d. be approximately 20 lm

C.E94; F.39

Optical Aids

198. A stereoscope is a device that:

- a. projects the contents of a pair of stereoradiographs on a screen giving spatial resolution to indications in the radiographs
- b. permits each eye to see only one of a pair of stereoradiographs
- c. by exposing two film cassettes simultaneously from different angles, enables the production of radiographs
- d. allows accurate measurements of the shift of an image in a set of stereoradiographs made for the purpose of parallax

A.20.21

Judging Radiographic Quality

Density

199. The density of any radiographic image is primarily dependent upon:

- a. the kilovoltage of the source of radiation
- b. the amount of radiation absorbed by the emulsion of the film
- c. both a and b
- d. neither a nor b

A.20.3

200. Incident light of intensity of 2.2 klx (200 ftc) on an area of film of 1.3 density transmits an intensity of 108 lx (10 ftc). What is the intensity transmitted in the area of the film measuring 2.3 density?

- a. 54 lx (5 ftc)
- b. 5.4 lx (0.5 ftc)
- c. 11 lx (1 ftc)
- d. 1.1 lx (0.1 ftc)

A.20.31-32

Contrast

201. The relationship between film exposure and the resulting film density of any particular film is:

- a. the unsharpness
- b. the film contrast
- c. the subject contrast
- d. none of the above

E.4-5

117. X-rays, gamma rays, and alpha particles all have one thing in common; they are all:

- a. particulate radiations
- b. electromagnetic radiations
- c. microwave radiations
- d. ionizing radiations

D.25

118. The term used to express the number of curies of radioactivity per gram or ounce of source weight is:

- a. decay
- b. emissivity
- c. specific activity
- d. source output

A.15.5; D.81; F.15

119. Atoms, molecules, and various subatomic particles that carry either a positive or negative electrical charge are called:

- a. photoelectrons
- b. photons
- c. ions
- d. compounds

A.5.16; D.25

120. Gamma and X-radiation interact with matter and may be absorbed by:

- a. photoelectric absorption
- b. Compton scattering
- c. pair production
- d. all of the above

A.13.18; D.27

121. Approximately what percent of the original radioactivity is left after 6 half-lives?

- a. 0.005
- b. 10
- c. 33.3
- d. 2

A.13.12; D.22

122. The velocity of all electromagnetic radiation is:

- a. 186 000 miles per second
- b. 18 600 miles per second
- c. 186 000 miles per second
- d. 1 860 miles per second

A.13.8; D.10

123. The radiation intensity of a radioisotope:

- a. increases with time
- b. decreases with time
- c. is not affected as time elapses
- d. none of the above

A.15.5

182. Better quality radiographs can be obtained when expertly done by manual processing rather than by automatic processing, but most processing is performed automatically because:

- a. manual processing is time consuming and automatic processing produces consistency
- b. it is difficult to train and keep manual processing personnel
- c. automatic processors are easier to maintain
- d. chemical temperatures and solutions are difficult to maintain in darkrooms where manual processing is practiced

G.151

183. The function of the developer is to:

- a. stop the process
- b. harden the emulsion
- c. recover silver
- d. change exposed silver halide crystals to metallic silver

F.39

184. The best method of arresting the development process is to place the film in:

- a. an acid stop bath
- b. a fixer solution
- c. a water rinse
- d. a wetting solution

F.85

185. The most important function of the fixer is to:

- a. neutralize alkali from developer
- b. remove undeveloped silver salt
- c. increase density
- d. harden the emulsion

F.85

186. Wetting agents are used primarily as a deterrent for:

- a. reticulation
- b. changes in density
- c. water spots
- d. frilling

F.39

187. In automatic processing, if the film emulsion becomes swollen, soft, or sticky, the result may be:

- a. slowdown of the transport system and overlap
- b. film sticking on a roller
- c. film wrapping around a roller
- d. all of the above

F.39

188. Ideally after processing, radiographs should be stored at a relative humidity of:

- a. 10 percent
- b. 30 to 50 percent
- c. 70 to 80 percent
- d. relative humidity is not an important consideration

F.39

189. In manual processing, the "cascade method" of washing film is desirable. To be effective, the hourly flow of water should be:

- a. 1-2 times the volume of the tank
- b. water flow rate has no bearing on film washing
- c. 12-16 times the volume of the tank
- d. 4-8 times the volume of the tank

F.39 (Supplement F.39); G.154

190. Holding all other parameters constant, an increase in time of development of a given film will result in a characteristic curve showing:

- a. increased contrast and increased speed
- b. increased contrast and decreased speed
- c. decreased contrast and increased speed
- d. decreased contrast and decreased speed

A.20.21

Illuminator Requirements

191. Which of the following is not a requirement for illuminators used in the interpretation of radiographs?

- a. a light source of sufficient intensity to view the area of interest of the radiograph
- b. sufficient masking to avoid glare from the edges of the radiograph
- c. a foot-operated ON-OFF switch
- d. none of the above

F.39

192. For the routine viewing of high-density film, a high-intensity illuminator with an adjustable light source should be used. Such a viewer should allow viewing of densities at least up to:

- a. 1.5 H&D
- b. 2.5 H&D
- c. 4.0 H&D
- d. 10.0 H&D

A.20.21

172. The shape of the film characteristic curve is relatively insensitive to changes in X- or gamma radiation quality but is affected by changes in the:
- a. geometric factors
 - b. film graininess
 - c. subject contrast
 - d. degree of development

F.65, 129

173. Light crimp marks appearing on a developed radiograph are the result of:

- a. static marks
- b. scratches on lead foil screen
- c. poor handling before exposure
- d. poor handling after exposure

F.148

174. Physical damage to the film emulsion caused by sudden extreme temperature change is called:

- a. reticulation
- b. frilling
- c. blisters
- d. streaks

F.150

175. The frequency with which a developer solution needs replacement is dependent on the rate and density of films processed but as a rule the solution should be replaced:

- a. whenever the density of processed films is consistently too great
- b. when the quantity of developer replenisher used equals 2-3 times the original quantity of developer, or every 3 months, whichever is shorter
- c. every 6 months
- d. whenever the processed films show streaking due to uneven development

A.21.6

Darkroom Equipment and Chemicals

176. When using acid to make the stop bath mixture, the acid is added slowly to the water for which of the following reasons?

- a. to produce a more uniform mixture
- b. to prevent rapid oxidation resulting in a cloudy stop bath
- c. to prevent a rapid rise of the solution temperature
- d. to prevent the acid from spattering

A.21.7

177. Certain materials cause contamination and result in fog in the radiograph. Which one of the following should not be used as a material for holding processing solutions?

- a. AISI Type 316 stainless steel
- b. enamelware
- c. aluminum
- d. plastic

F.39

178. Processing tanks should be periodically cleaned and sterilized. Which of the following agents in solution is recommended?

- a. sodium hypochlorite
- b. acetone
- c. household detergent
- d. hydrochloric acid (diluted)

F.39

179. The most commonly used acid in preparing stop baths to arrest the development process is:

- a. sulfuric
- b. glacial acetic
- c. muriatic
- d. hydrochloric

A.20.21; F.39

Film Processing

180. In manual processing, if it is not possible to use a stop bath, films should be:

- a. placed directly in the fixer solution
- b. placed directly in the fixer solution with a 1 minute reduction in development time
- c. rinsed in running water for at least 2 minutes before fixing
- d. rinsed in running water for at least 2 minutes with a 1-minute reduction in development time before fixing

F.85

181. The primary reason why visual (under safelight conditions) development of radiographs should be avoided is:

- a. it is difficult to discern the image with the light output provided by a safelight
- b. the appearance of a developed but unfixed radiograph will be different in the dried state
- c. removal of the film from the developer will affect the development time
- d. film type and speed affect the appearance of images when exposed to a safelight

F.39

Level I Answers
Radiographic Testing Method

1. c

2. d

3. c

4. b

5. d

6. a

7. c

8. b

9. c

10. d

11. c

12. b

13. b

14. b

15. a

16. a

17. a

18. c

19. b

20. d

21. d

22. c

23. a

24. c

25. c

26. b

27. d

28. a

29. b

30. a

31. c
32. d

33. a

34. d

35. c

36. b

37. c

38. a

39. b

40. d

41. c

42. c

43. c

44. b

45. d

46. a

47. b

48. d

49. b

50. d

51. b

52. c

53. d

54. d

55. a

56. b

57. b

58. b

59. d

60. b

61. b

62. a
63. d

64. c

65. b

66. c

67. b

68. b

69. d

70. c

71. b

72. a

73. d

74. c

75. b

76. b

77. b

78. a

79. c

80. a

81. c

82. b

83. b

84. a

85. b

86. c

87. c

88. c

89. d

90. c

91. b

92. b

93. b
94. c

95. c

96. c

97. d

98. b

99. b

100. c

101. a

102. a

103. d

104. c

105. c

106. d

107. c

108. a

109. b

110. e

111. c

112. b

113. a

114. c

115. b

116. a

117. d

118. c

119. c

120. d

121. d

122. a

123. b

162. Which is generally the greater source of scatter radiation?

- a. lead foil screens
- b. lead backing plate
- c. floor or wall
- d. the specimen under examination

F.39

Exposure Curves

167. Which one of the following is not a specific condition which applies to a given exposure chart?

- a. X-ray machine used
- b. film type
- c. processing conditions
- d. radiation intensity
- e. film density on which the chart is based

F.39

Source Factors

163. Short wavelength photons are normally used on thick sections of steel instead of long wavelength photons because:

- a. short wavelength photons are hard rays and have greater penetrating ability
- b. short wavelength photons create a greater secondary radiation and help improve image contrast
- c. long wavelength photons are hard rays and have greater penetrating ability
- d. they both have equal penetrating ability

A.20.4; F.10-21

164. A lead sheet is usually placed behind the film cassette to:

- a. intensify the film image and shorten the exposure time
- b. prevent bending and crimping of the film
- c. reduce forward scatter and absorb unwanted radiation to prevent it from reaching the film
- d. minimize radiation scattered from the floor, walls, equipment, and other items from reaching the back of the film

A.20.21

165. The larger the activity (in curies) and the larger (physically) the source is, the emitted gamma ray intensity per curie:

- a. becomes lower
- b. becomes higher
- c. remains unaffected
- d. increases inversely to activity

A.20.21

Darkroom Procedures

171. In manual processing, the ideal temperature is 20 °C (68 °F). At what temperature would the chemical action be slowed, resulting in underdevelopment?

- a. 21 °C (70 °F)
- b. 16 °C (60 °F)
- c. 32 °C (90 °F)
- d. none of the above

A.21.4; F.83

166. When radiographing a specimen with a radiographic source, it is found that it is desirable to lengthen the source-to-film distance. With the source at the new location, the amount of radiation reaching the film will:

- a. vary inversely with the square of the distance
- b. vary equally with the square of the distance
- c. will not change
- d. vary inversely with the distance

A.20.10

152. The Bunsen-Roscoe reciprocity law states that the product of a photochemical reaction is dependent only upon the product of the radiation intensity and the duration of exposure and is independent of the absolute values of either of these quantities separately. This law is invalid for which of the following?

- a. X-rays
- b. gamma rays
- c. fluorescent screens
- d. lead foil screens

A.16.23

153. The quality of the radiation necessary to obtain an appreciable intensification from lead screens depends upon all the following except:

- a. film type
- b. kilovoltage
- c. milliamperage
- d. thickness and material of test object

A.20.27

154. An alloy of 6 percent antimony and 94 percent lead should be used for screens instead of pure lead because it provides:

- a. greater definition
- b. less mottling effect
- c. better wear resistance
- d. a higher intensification factor

A.20.27

155. The intensifying action of a lead foil screen is caused by:

- a. the addition of 6 percent antimony to the lead
- b. the electrons emitted under gamma or X-ray excitation
- c. preferential absorption by the lead atoms
- d. characteristic and scattered radiation originating in the screen

D.94

156. In comparison to radiographs made with lead screens, radiographs made using fluorescent screens would show:

- a. better contrast
- b. good definition
- c. higher density
- d. poor definition

F.36

157. Variation in the thickness of lead screens from 0.1 mm (0.005 in.) to 0.2 mm (0.01 in.):

- a. has very slight effect on intensification
- b. has very significant effect on intensification
- c. actually has no effect on intensification
- d. only serves to increase geometric unsharpness

A.16.24

Scattered Radiation

158. Scatter radiation caused by the specimen being radiographed is usually called:

- a. backscatter
- b. side scatter
- c. undercut
- d. forward scatter

D.89

159. The major component of scatter is the low-energy rays represented by photons weakened in what process?

- a. photoelectric
- b. pair productive
- c. Compton scattering
- d. ionization

E.2-14

160. The influence of low-energy scatter from the film holder is most noticeable just inside the borders of the image. This condition is called:

- a. inherent unsharpness
- b. undercut
- c. geometric unsharpness
- d. mottling

F.39

161. The difference in narrow-beam and broad-beam conditions is that:

- a. narrow-beam conditions imply that both scattered and unscattered radiation reach the detector, while broad-beam conditions imply that only the unscattered radiation reaches the detector
- b. narrow-beam conditions imply that only the unscattered radiation reaches the detector, while broad-beam conditions imply that both scattered and unscattered radiation reach the detector
- c. narrow- and broad-beam conditions relate only to source size
- d. both terms depend on film and screen combination

A.15.35-37

Level II Questions
Radiographic Testing Method

1. Low voltage X-ray tubes are generally fitted with windows made of:

- a. plastic
- b. beryllium
- c. glass
- d. lead

A.14.12

2. A monochromatic X-ray beam is:

- a. a narrow beam used to produce high-contrast radiographs
- b. also referred to as a heterogeneous X-ray beam
- c. a beam containing only characteristic X-radiation
- d. a beam consisting of a single wavelength

D.15

3. The general method of producing X-rays involves the sudden deceleration of high velocity electrons in a solid body called a:

- a. focus cup
- b. filament
- c. target
- d. cathode

A.14.1

4. If it were necessary to radiograph a 18 cm (7 in.) thick steel product, which of the following gamma ray sources would most likely be used?

- a. Co-60
- b. Tm-170
- c. Ir-192
- d. Cs-137

F.17

5. A Co-60 gamma ray source has an approximate practical thickness limit of:

- a. 63 mm (2.5 in.) of steel or its equivalent
- b. 102 mm (4 in.) of steel or its equivalent
- c. 23 cm (9 in.) of steel or its equivalent
- d. 28 cm (11 in.) of steel or its equivalent

F.17

6. The absorption of gamma rays from a given source when passing through matter depends on the:

- a. atomic number, density, and thickness of the matter
- b. Young's modulus value of the matter
- c. Poisson's ratio value of the matter
- d. specific activity value of the source

D.149; F.26

7. The fact that gases, when bombarded by radiation, ionize and become electrical conductors make them useful in:

- a. X-ray transformers
- b. X-ray tubes
- c. masks
- d. radiation detection equipment

A.16.1

8. The velocity of electrons striking the target in an X-ray tube is a function of the:

- a. atomic number of the cathode material
- b. atomic number of the filament material
- c. voltage difference between the cathode and anode
- d. current flow in the rectifier circuit

D.14

9. The uneven distribution of developed grains within the emulsion of a processed X-ray film causes the subjective impression of:

- a. graininess
- b. streaks
- c. spots
- d. white scum

A.16.21

Note: If questions 10 or 11 are used on a test, the examinee should be furnished with semilogarithmic coordinate paper.

10. Co-60 is reported to have a half-life of 5.3 years. By how much should exposure time be increased (over that used initially to produce excellent radiographs when the Co-60 source was new) when the source is two years old?
- a. no change in exposure time is needed
b. exposure time should be about 11 percent longer
c. exposure time should be about 31 percent longer
d. exposure time should be about 62 to 100 percent longer
- A.15.5**
11. A source of Ir-192, whose half-life is 75 days, provides an optimum exposure of a given test object today in a period of 20 minutes. Five months from now, what exposure time would be required for the same radiographic density, under similar exposure conditions?
- a. 10 minutes
b. 20 minutes
c. 1 hour and 20 minutes
d. 6 hours
- A.15.5; E.2-19**
12. Of the following, the source providing the most penetrating radiation is:
- a. Co-60
b. 220 kVp X-ray tube
c. 15 MeV X-ray betatron
d. electrons from Ir-192
- A.14.19**
13. The gamma ray intensity at 30 cm (1 ft) from a 37 GBq (1 Ci) source of radioactive Co-60 is nearest to:
- a. 15 roentgens per hour
b. 1 000 roentgens per hour
c. 1 roentgen per minute
d. 10 milliroentgens per day
- A.15.13; D.36**
14. The focal spot in an X-ray tube:
- a. is inclined at an angle of 30° from the normal to the tube axis
b. is maintained at a high negative voltage during operations
c. should be as large as possible to ensure a narrow beam of primary radiation
d. should be as small as possible without unduly shortening the life of the tube
- F.9-10**
15. In an X-ray tube, the filament and focusing cup are the two essential parts of the:
- a. anode
b. cathode
c. rectifier
d. X-ray transformer
- F.9**
16. The quantity of radiation which will produce, by means of ionization, one electrostatic unit of electricity in 0.001293 g of dry air is known as a:
- a. millicurie
b. gamma
c. roentgen
d. curie
- F.15**
17. The specific activity of an isotopic source is usually measured in:
- a. million electron volts (MeV)
b. curies per gram (Ci/g)
c. roentgens per hour (R/h)
d. counts per minute (cpm)
- A.15.5; E.2-19**
18. Which of the following isotopes has the longest half-life?
- a. Tm-170
b. Co-60
c. Ir-192
d. Cs-137
- A.15.13; E.3-16**
19. The primary form of energy conversion when electrons strike a target in an X-ray tube results in the production of:
- a. primary X-rays
b. secondary X-rays
c. short wavelength X-rays
d. heat
- E.3-6**
20. The slope of a straight line joining two points of specified densities on a characteristic curve of a film is known as the:
- a. speed of the curve
b. latitude
c. average gradient
d. density
- F.126**

141. The size of the penumbral shadow can best be reduced by:

- a. using a larger diameter source
b. using a faster speed film
c. increasing the source-to-film distance
d. increasing the specimen-to-film distance

E.2-5

142. Deviation from the true shape of an object as exhibited in its shadow image is called:

- a. definition
b. latitude
c. contrast
d. distortion

A.20.6; F.19

143. Which of the following rules of shadow formation is not true?

- a. the effective focal spot or source size should be as small as practical
b. the distance between the focal spot or source and the test object should be as great as practical
c. the central ray should be as nearly perpendicular to the film as possible to preserve spatial relations
d. the test object's plane of maximum interest should be perpendicular to the plane of the film

F.3-20

144. Given an Ir-192 source 3 mm (0.13 in.) in diameter, a geometrical unsharpness of 0.5 mm (0.02 in.) and a material thickness of 63 mm (2.5 in.), determine the minimum source-to-object distance.

- a. 32 cm (12.6 in.)
b. 62 cm (24.6 in.)
c. 40 cm (15.6 in.)
d. 46 cm (18.1 in.)

F.3-21

145. Projection magnification resulting from increased object-to-film distance is also useful in reducing scatter radiation because of:

- a. increasing definition
b. reducing physical source size
c. the air gap
d. macroradiography

A.20.10

146. Magnification and geometric unsharpness:

- a. are actually the same thing
b. can be distinguished as follows: magnification refers to the degree of enlargement, and unsharpness refers to the penumbra
c. are not directly related
d. can be combined to yield total unsharpness

A.20.5-8

147. Geometric unsharpness (U_s) is obtainable from:

a. $U_s = \frac{Ft}{d}$

where
 F = source size

d = source-to-object distance
 t = object-to-film distance

b. $U_s = \frac{d}{Ft}$

c. $U_s = \frac{Fd}{t}$

d. $U_s = \frac{t}{Fd}$

A.20-8; F.21

148. Using the formula $U_s = \frac{Ft}{d}$, if $F = 3$ mm (0.1 in.), $t = 127$ mm (5 in.), and $d = 109$ cm (43 in.), U_s is approximately:

- a. 0.5 mm (0.02 in.)
b. 0.7 mm (0.02 in.)
c. 4 mm (0.014 in.)
d. 0.2 mm (0.006 in.)

A.20.8

149. Image distortion refers to:

- a. a combination of geometric unsharpness and magnification
b. deviation from the true shape of the object
c. magnification minus geometric unsharpness
d. a combination of graininess, unsharpness, and magnification

A.20.6

Intensifying Screens

150. The most commonly used intensifying material in fluorescent screens for industrial radiography is:

- a. zinc sulfide
b. calcium sulfide
c. cesium iodide
d. calcium tungstate

H.16

151. Fluorometallic intensifying screens, compared with lead foil screens, can reduce the exposure time by factors up to:

- a. 100
b. 10
c. 500
d. 1

H.16

135. The sharpness of outline in a radiographic image is called:

- a. definition
- b. sensitivity
- c. latitude
- d. contrast

F.67

136. Poor radiographic definition could be the result of:

- a. focal spot size
- b. source-to-film distance
- c. poor film-screen contact
- d. all of the above

F.66

Geometric Factors

137. Another term frequently used to describe geometrical unsharpness is:

- a. radiographic distortion
- b. penumbral shadow
- c. radiographic enlargement
- d. geometric enlargement

A.20.8

138. Using Figure 8, determine the geometrical unsharpness under the following conditions. Maximum specimen thickness is 38 mm (1.5 in.), source-to-film distance is 102 cm (40 in.), and the focal spot size is 1 mm (0.04 in.). The geometrical unsharpness is:

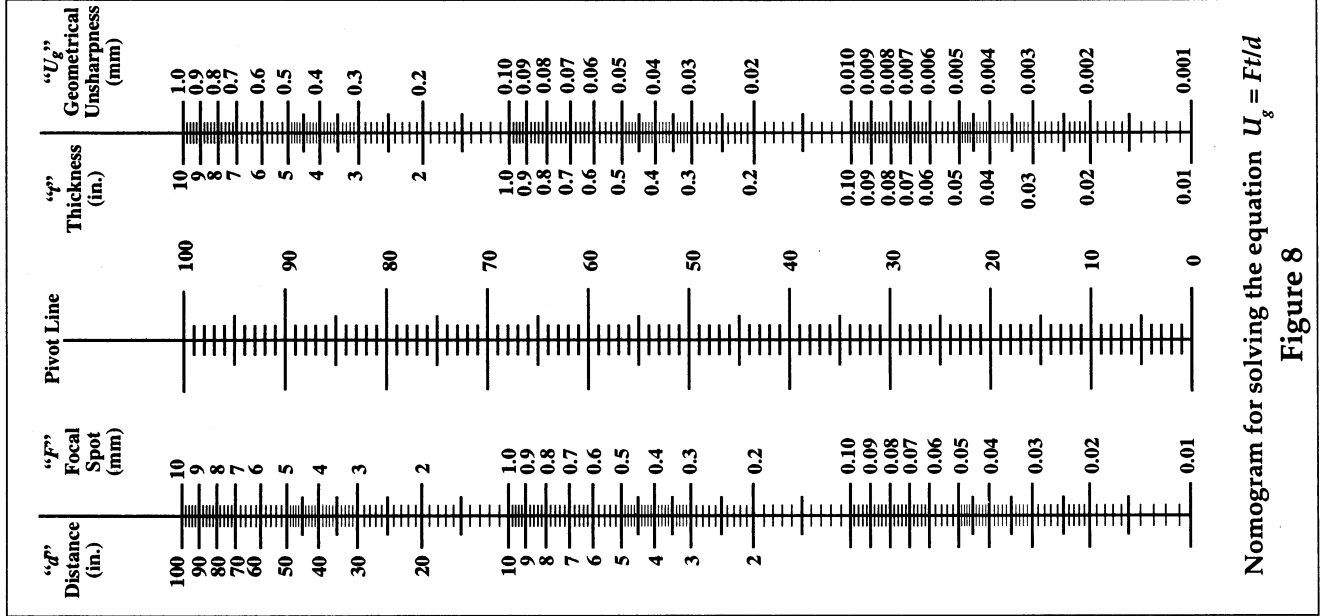
- a. 0.010 mm (0.0004 in.)
- b. 0.100 mm (0.004 in.)
- c. 0.04 mm (0.002 in.)
- d. 0.25 mm (0.01 in.)

A.20.9

139. Which of the following is not a factor to be considered to reduce geometric unsharpness?

- a. source-to-film distance
- b. object-to-film distance
- c. source strength
- d. source size

A.20.7



Nomogram for solving the equation $U_g = Ft/d$
Figure 8

140. In the following equation for geometric unsharpness,

what does U_g represent? $U_g = \frac{Ft}{d}$

- a. image size
- b. penumbra
- c. source-to-film distance
- d. specimen-to-film distance

A.20.8

21. An X-ray film having wide latitude also has, by definition:

- a. poor definition
- b. low contrast
- c. high speed
- d. none of the above

F.67-69

22. The purpose for circulating oil in some types of X-ray tubes is to:

- a. lubricate moving parts
- b. absorb secondary radiation
- c. decrease the need for high current
- d. dissipate heat

A.14.33

23. An X-ray tube with a small focal spot is considered better than one with a large focal spot when it is desired to obtain:

- a. greater penetrating power
- b. better definition
- c. less contrast
- d. greater film density

F.18-22

24. One method of reducing radiographic contrast is to:

- a. increase the distance between the radiation source and the object
- b. decrease the distance between the object and the film
- c. decrease the wavelength of the radiation used
- d. increase development time within manufacturer's recommendations

F.29

25. Thin sheets of lead foil in intimate contact with X-ray film during exposure increase film density because they:

- a. fluoresce and emit visible light which helps expose the film
- b. absorb the scattered radiation
- c. prevent backscattered radiation from fogging the film
- d. emit electrons when exposed to X- and gamma radiation which help darken the film

A.16.24

26. X-ray tubes are often enclosed in a shockproof casing in order to:

- a. dissipate heat
- b. protect the operator from high-voltage shock
- c. shield the tube from secondary radiation
- d. increase the efficiency of the rectifier

E.5.24

27. An X-ray tube is rated for a maximum of 250 kVp. This tube may be operated at a maximum of:

- a. 250 000 V peak voltage
- b. 250 kV effective voltage
- c. 250 000 000 V rms voltage
- d. 250 kV average voltage

A.14.12

28. A voltage selector consisting of an iron core transformer with a single winding having a series of taps at various points on the winding is called:

- a. a high-voltage transformer
- b. a filament transformer
- c. an autotransformer
- d. a power transformer

F.10-11

29. In X-ray radiography, alternating current must be changed to pulsating direct current in order to satisfy the need for unidirectional current. This change may be accomplished by:

- a. transformers
- b. rectifiers
- c. anodes
- d. cathodes

F.11

30. When radiographing to the 2-2T quality level, an ASTM penetrometer for 63 mm (2.5 in.) steel has a thickness of:

- a. 13 mm (0.5 in.)
- b. 64 μ m (2.5 mils)
- c. 127 μ m (5 mils)
- d. 1270 μ m (50 mils)

C.E94

31. Valve tubes are used in X-ray equipment to:

- a. provide necessary rectification
- b. activate and deactivate the X-ray tube
- c. heat the filaments in the X-ray tube
- d. adjust the size of the target

A.14.6; B.96-97

32. A good Co-60 radiograph is made on a 76 mm (3 in.) steel casting using an exposure time of 10 minutes and a source-to-film distance of 91 cm (36 in.). If it is necessary to change the source-to-film distance to 61 cm (24 in.), what exposure time would produce a similar radiograph if all other conditions remain the same?

- a. 1.6 minutes
- b. 4.4 minutes
- c. 6.4 minutes
- d. 8.8 minutes

F.47

33. When sharp, black, bird-foot shaped marks which are known not to correspond with any discontinuities appear at random on radiographs, they are probably caused by:

a. prolonged development in old developer

b. exposure of the film by natural cosmic ray showers during storage

c. static charges caused by friction

d. inadequate rinsing after fixing

F.148

34. The adjustment of tube current in conventional X-ray tube circuits is made by:

a. adjusting the filament heating current

b. adjusting the target-to-cathode distance

c. inserting resistance in the anode lead

d. opening the shutter on the X-ray tube port

F.9

35. In comparison with lower-voltage radiographs, high-energy radiographs show:

a. greater contrast

b. greater latitude

c. greater amounts of scatter radiation relative to primary beam intensity

d. none of the above

A.23.4-5

36. Filters used at the port of the X-ray tube:

a. intensify the X-ray beam by contributing secondary radiation

b. filter short wavelength X-ray beams to provide "softer" radiation

c. provide the most readily adjusted means of modifying X-ray intensity

d. filter out "soft" radiation to provide a more homogeneous X-ray beam

F.42

37. An ASTM penetrameter for use when inspecting a 13 mm (0.5 in.) thick steel plate to the 2-2T quality level using a 41 cm (16 in.) source-to-film distance would be made of:

a. 127 μm (5 mil) thick aluminum

b. 1270 μm (50 mil) thick aluminum or steel

c. 254 μm (10 mil) thick steel

d. 51 μm (2 mil) strip of any metallic material

C.E94

38. Filters placed between the X-ray tube and specimen tend to reduce scatter radiation undercutting the specimen by:

a. absorbing the longer wavelength components of the primary beam

b. absorbing the shorter wavelength components of the primary beam

c. absorbing backscatter radiation

d. decreasing the intensity of the beam

F.42

39. Besides serving as a filter, screens of high atomic numbers, such as lead and lead antimony, also:

a. decrease the source-to-film distance needed for a proper radiograph

b. provide some image intensifying action

c. permit the use of higher speed film

d. decrease the graininess in a radiograph

F.32

40. The range of thickness over which densities are obtained that are satisfactory for interpretation is a measure of the:

a. subject contrast of a radiograph

b. sensitivity of a radiograph

c. latitude of a radiograph

d. definition of a radiograph

A.23.4

41. Almost all gamma radiography is performed with:

a. natural isotopes

b. Ir-192 or Co-60

c. radium

d. Tm-170

A.15.7, 15.13; E.3-16

42. The amount of unsharpness or blurring of a radiograph is:

a. directly proportional to the object-to-film distance and inversely proportional to the size of the focal spot

b. directly proportional to the size of the focal spot and inversely proportional to the source-to-object distance

c. inversely proportional to the object-to-film distance and directly proportional to the source-to-object distance

d. inversely proportional to the size of the focal spot and the object-to-film distance

F.18-22
- Contrast and Definition
125. Which of the following parameters does not directly affect radiographic definition?

a. focal spot or source size

b. density

c. type of screen

d. radiation quality

F.66

126. Using a filter at the X-ray tube, masking to lessen the thickness range, and a multiple-film technique are ways of correcting:

a. low density

b. low latitude

c. poor definition

d. low radiographic contrast

F.147

127. Poor definition can be improved by doing all but which one of the following?

a. increase source-to-film distance

b. use a smaller physical source size

c. change from Class II to Class I film

d. change from lead to fluorescent screens

F.148

128. Based on the characteristic curves of the films shown in Figure 7, which film provides the highest contrast?

a. X

b. Y

c. Z

d. cannot be determined from the curves

F.124

129. Subject contrast depends on:

a. mA, source strength, distance, and film type

b. film-screen type

c. nature of the specimen, radiation quality (KV), and the intensity and distribution of the scattered radiation

d. Lambert's law

A.20.34

130. Film contrast refers to:

a. the density difference in two adjacent regions of film

b. the steepness (slope) of the characteristic curve

c. the ratio of X-ray or gamma ray intensities transmitted by two selected portions of a specimen

d. minimum perceptible density change

A.20.35

131. In general, the contrast of radiographic films (except those designed for use with fluorescent screens):

a. increases continuously with film density in the usable density range

b. decreases as the density is increased

c. remains practically unchanged for different density levels

d. is inversely proportional to film density

A.20.35

132. The graininess of all films:

a. increases as the kilovoltage is increased up to approximately 200 kV

b. decreases as the kilovoltage is increased

c. is not dependent on kilovoltage

d. is totally controlled by Lambert's law

A.20.36

133. Which of the following is not a factor in radiographic contrast?

a. film type

b. radiation quality

c. degree of film development

d. none of the above

C.E94; F.29

134. Specimens with uniform thickness and composition by definition have:

a. high subject contrast

b. good definition

c. high film contrast

d. low subject contrast

D.92
-
- Figure 7
- 24
- Radiographic Testing Method, Level III
- 53

Sensitivity

115. Radiographic sensitivity depends on the combined effects of two independent factors. One is radiographic contrast; the other is:

- a. radiation quality
- b. density
- c. penetrameter image
- d. definition

F.67

116. Using the equation $\alpha = \frac{100}{x} \sqrt{Th / 2}$

where

α = 20% = percent equivalent penetrameter sensitivity

x = 32 mm (1.25 in.) = section thickness to be radiographed

T = penetrameter thickness

h = 1.6 mm (0.06 in.) = hole diameter

determine penetrameter thickness:

- a. 41 mm (1.6 in.)
- b. 0.5 mm (0.02 in.)
- c. 0.4 mm (0.015 in.)
- d. 0.8 mm (0.03 in.)

C.E142

117. Radiographic sensitivity is:

- a. a general or qualitative term referring to the size of the smallest detail which can be seen on a radiograph
- b. only a measure of the contrast properties of the radiographic system
- c. a term usually applied to the contrast properties of the radiographic system
- d. a term which reflects film speed and contrast properties

A.20.34; F.67

118. Radiographic sensitivity is totally controlled by:

- a. film and screen combinations
- b. those factors which control radiographic contrast and definition
- c. kilovoltage and milliamperage
- d. kilovoltage and film processing

A.20.34; F.67

119. The visibility of a certain penetrameter hole on the radiograph may mean that:

- a. a cavity of the same diameter will be visible
- b. a cavity of half the hole diameter will be visible
- c. a cavity of the same diameter may be invisible
- d. the hole and cavity will have equal detectability

A.20.38

120. The penetrameter is used to:

- a. determine the size of cracks and pores that can be detected
- b. determine the crack depths that can be detected
- c. determine critical flaw size
- d. indicate the quality of the radiographic technique

A.20.38

121. The sensitivity requirement 2-2T represents:

- a. penetrameter thickness 2X the specimen thickness with the required penetrameter hole 2 percent of the specimen thickness
- b. penetrameter thickness 2 percent of specimen thickness with the required penetrameter hole 2X the penetrameter thickness
- c. penetrameter thickness 2 percent of the specimen thickness with the required penetrameter hole 2 percent of the specimen thickness
- d. penetrameter thickness 2 percent of the specimen thickness with the required penetrameter hole 4 percent of the penetrameter thickness

C.E94

122. The term radiographic sensitivity usually refers to the ability of a radiographic technique to detect discontinuities. In practice, sensitivity is specified as:

- a. the measurable unsharpness on a radiograph
- b. the ratio of the smallest thickness difference visible on the radiograph to the thickness of the material being examined
- c. the density difference between two areas
- d. the degree of concentration of a radioactive source

D.125

123. The image quality indicator (penetrameter) should not be used to:

- a. judge the size or establish acceptance limits of discontinuities
- b. judge the adequacy of a radiographic exposure
- c. determine film/screen combinations adequacy
- d. judge the adequacy of part-to-film distance

E.6-10

124. Radiographic sensitivity is affected by:

- a. subject contrast
- b. geometric and film graininess factors
- c. film contrast
- d. all of the above

F.66

49. The purpose for including a disc-shaped target that rotates rapidly during operation in some X-ray tubes is to:

- a. increase the intensity of X-radiation
- b. decrease the voltage needed for a specific quality of radiation
- c. increase the permissible load
- d. none of the above

A.14.4

50. A device which is basically a combination of magnet and transformer designed to guide and accelerate electrons in a circular orbit to very high energies is called a:

- a. electrostatic belt generator
- b. linear accelerator
- c. betatron
- d. toroidal electromagnetic type X-ray tube

A.14.18

51. Two isotropic sources of a given strength have two different specific activity values. The source with the higher specific activity value will:

- a. have a smaller physical size than the source with a lower specific activity
- b. have a shorter half-life than the source with a lower specific activity
- c. produce harder gamma rays than the source with a lower specific activity
- d. have a larger physical size than the source with the lower specific activity

A.15.5

52. A gas-filled region located in an electrical field created by electrodes across which a potential difference is applied forms the major portion of:

- a. a low voltage X-ray tube
- b. a megger
- c. a hot cathode X-ray tube
- d. an ionization chamber

A.16.2

53. Two serious obstacles to high-intensity fluoroscopy are:

- a. the inability to reproduce results and the need for periodic replacement of screens
- b. the limited brightness and large grain size of fluoroscopic screens
- c. cost and slow speed
- d. the need for using long wavelength X-rays and the lack of X-ray intensity associated with this method

A.19.1

54. In general, the quality of fluoroscopic equipment is best determined by:

a. densitometer readings
b. penetrameter sensitivity measurements
c. discontinuity area measurements
d. reference standards

A.19.36

55. In fluoroscopic testing, a fundamental difficulty is the relative low brightness level of the images. One method for increasing brightness utilizes one of the following which converts light energy from the initial phosphor surface to electrons which are accelerated and focused onto a smaller fluorescent screen.

a. betatron
b. electron amplifier
c. image amplifier or intensifier
d. electrostatic belt generator

A.19.37

56. A general rule governing the application of the geometric principles of shadow formation states that the:

a. X-rays should proceed from as large a focal spot as other considerations will allow
b. distance between the radiation source and the material examined should be as small as practical
c. film should be as far as possible from the object being radiographed
d. central ray should be as nearly perpendicular to the film as possible to preserve spatial relationships

A.20.7

57. In order to utilize the principles of geometric enlargement (placing the film at a distance from the specimen):

a. the source-to-specimen distance must be half the source-to-film distance
b. the source of radiation must be extremely small
c. a magnetic focusing coil must be used near the port of the X-ray tube
d. the specimen must be of uniform thickness

A.20.10

58. The radiographic absorption of a material will tend to become less dependent upon the composition of the material when:

a. the kilovoltage is increased
b. the source-to-film distance is decreased
c. the kilovoltage is decreased
d. a filter is used

A.20.13-15

59. The formula (milliamperes × time) ÷ distance² is:

a. used to calculate film gradient
b. the reciprocity law
c. used to determine radiographic contrast
d. the exposure factor

A.20.15; F.28

60. The load that can be handled by an X-ray tube focal spot is governed by:

a. the composition of the cathode
b. the size of the focal spot and the efficiency of the cooling system of the anode
c. the distance from the anode to the cathode
d. the high-voltage waveform

A.14.29

61. X-ray exposure holders and cassettes often incorporate a sheet of lead foil in the back which is not in intimate contact with the film. The purpose of this sheet of lead foil is:

a. to act as an intensifying screen
b. to protect the film from backscatter
c. both a and b
d. neither a nor b

A.20.21

62. A lead sheet containing a pinhole may be placed halfway between the X-ray tube and the film in order to:

a. determine the approximate size of the focal spot
b. measure the intensity of the central ray
c. filter scatter radiation
d. soften the X-radiation

A.14.32

63. In certain cases, it may be advantageous to pack lead shot around a specimen. The purpose for doing this is to:

a. prevent movement of the specimen
b. increase the subject contrast
c. generate smaller wavelength X-radiation
d. decrease the effect of scattered radiation undercutting the specimen

A.20.22

64. When radiographing steel with a thickness less than 25 mm (1 in.):

a. Co-60 would give greater radiographic sensitivity than a 250 kV X-ray machine
b. a 250 kV X-ray machine would give greater radiographic sensitivity than Co-60
c. the use of fluorescent screens would result in a radiograph of better quality than would lead foil screens
d. the use of lead foil screens will require a shorter exposure time than will fluorescent screens

A.15.14; F.13
- Methods of Controlling Radiation Exposure
105. Distance is an effective means of external radiation protection because:

a. air absorption reduces the radiation intensity
b. radiation intensity varies inversely as the square of the distance
c. X-rays and gamma rays have a finite range
d. the wavelength of the photons is decreased by their interaction with matter

D.28

106. X-ray photons differ from gamma photons of the same energy only in their:

a. biological effect
b. origin
c. interaction
d. wavelength

D.11

107. Filters of different thicknesses of material are often incorporated into film badges used for beta-gamma dosimetry. The purpose of these filters is to:

a. attenuate the higher energy radiation
b. increase the sensitivity of the film to low energy radiation
c. ensure that no alphas reach the film
d. permit evaluation of the type and energy of the radiation

D.42

108. The half-life of a radioactive substance is equal to the:

a. reciprocal of the disintegration constant
b. average lifetime of an atom in the substance
c. time required for half of the original atoms to disintegrate
d. number of atoms present divided by the rate of decay

D.22

109. An individual is 30 years old. According to the 5(N-18) formula and the "banking concept" for determining exposure, this individual may receive a maximum permissible dose of:

a. 2.5 Sv (245 rem)
b. 0.65 Sv (65 rem)
c. 0.60 Sv (60 rem)
d. 2.7 Sv (270 rem)

A.26.3

110. A tenth value thickness for a specific gamma source is 25 mm (1 in.) of lead. The radiation intensity is 500 R/h at 61 cm (24 in.) from the source. How many inches of lead would be required to reduce the intensity to 5 mR/h at 61 cm (24 in.)?

a. 51 mm (2 in.)
b. 13 cm (5 in.)
c. 25 cm (10 in.)
d. 10 cm (4 in.)

A.26.9; D.32

111. Permissible personnel radiation exposure rates are based upon which of the following?

a. radiation equivalent man
b. banking concept
c. physical attributes
d. dose absorption rate

E.5-5
- Radiographic Testing Method, Level III
- Operational and Emergency Procedures
112. Radioisotope radiographic exposure devices, measuring less than 10 cm (4 in.) from the sealed source storage position to any exterior surface, shall have a dose rate at 15 cm (6 in.) from the surface of no greater than:

a. 2 mR/h
b. 50 mR/h
c. 10 mR/h
d. 200 mR/h

D.142

113. Survey instruments used to monitor gamma radiation must be capable of measuring radiation in the range of:

a. 0-2 000 mR/h
b. 2 mR/h-10 000 mR/h
c. 0-200 mR/h
d. 2 mR/h-1 000 mR/h

D.142

114. A radiation area refers to any area accessible to personnel in which radiation exists such that an individual could receive in any 1 h a dose exceeding:

a. 20 μSv (2 millirems)
b. 1 mSv (100 millirems)
c. 0.05 mSv (5 millirems)
d. 5 mSv (500 millirems)

D.143
- 26
- 51

95. Which of the following detectors would be most suitable for use with a gamma or X-ray energy spectrum analyzer?

- a. an ionization detector
- b. a scintillation detector
- c. a proportional detector
- d. a Geiger-Müller counter

A.18.22

96. Which of the following radiation measurement instruments does not employ gas detection as its operation mechanism?

- a. proportional counter
- b. semiconductor detector
- c. ionization chamber
- d. Geiger-Müller counter

A.16.1-9

Gaging and Control Processes

97. A system of X-ray thickness gaging in which X-rays are collimated and projected through a test item and the quantity of unabsorbed radiation is measured is referred to as:

- a. fluorescence method
- b. absorption differential method
- c. attenuation “buildup” method
- d. transmission method

A.18.6

98. Generally, the sensitivity and accuracy of thickness gaging of homogeneous materials by reflection methods is:

- a. superior to transmission gaging
- b. superior to fluorescence methods
- c. inferior to transmission gaging
- d. approximately the same as with transmission gaging

A.18.6

99. The two types of detectors used most commonly in X-ray thickness gages are:

- a. fluorescent screens and ionization chambers
- b. proportional counters and Geiger counters
- c. phosphor-photomultipliers and ionization chambers
- d. fluorescent screens and phosphor-photomultipliers

A.18.7

Exposure Hazards

100. A radiation level of 100 mR/h is noted at the perimeter of your posted high radiation area. This perimeter is 25 cm (10 ft) from the exposed source. Approximately how far away from the source should the radiation area signs be posted for the 2 mR/h line?

- a. 102 cm (40 ft)
- b. 254 cm (100 ft)
- c. 178 cm (70 ft)
- d. 318 cm (125 ft)

D.28

101. Which one of the following is not a characteristic to be given major consideration in selecting a radiographic survey instrument?

- a. window thickness-radiation detected
- b. dose rate range(s)
- c. time constant
- d. battery supply

D.43-44

102. With appropriate controls, the allowable radiation limits in unrestricted areas should not exceed:

- a. 5 µSv (0.5 rem) per calendar year
- b. 20 µSv (2 millirems) in any 1 h
- c. 1 mSv (100 millirems) in 7 consecutive days
- d. all of the above

D.139

103. A “leaking” source of radioactive material is considered a potentially hazardous situation. At what removable activity level is a sealed radiography source, by regulation, considered to be leaking?

- a. 5 aBq (0.05 mCi)
- b. 50 aBq (0.5 mCi)
- c. 0.5 aBq (0.005 mCi)
- d. 0.05 aBq (0.0005 mCi)

D.149

104. Sources of radioactive material used for radiography are required by regulation to be leak tested at intervals not to exceed:

- a. 6 months
- b. 3 months
- c. 12 months
- d. 24 months

D.149

70. The term which describes the total absorption of the useful beam caused by the X-ray tube wall, the wall of the tube housing, and any material between the tube and housing is:

- a. stray absorption
- b. source absorption
- c. characteristic filtration
- d. inherent filtration

A.19.17

71. The interval between the time a film is placed in a fixer solution and the time when the original diffuse, yellow milkiness disappears is known as:

- a. clearing time
- b. fixing time
- c. hardening time
- d. oxidation time

A.21.7

72. Improper geometric factors, poor contact between film and lead foil screens, and graininess of film are possible causes of:

- a. high film density
- b. poor definition
- c. fogged film
- d. low film density

A.21.19

73. In fluoroscopy, the most common way to minimize operator fatigue is to:

- a. equip operators with special glasses
- b. place a filter over the viewing screen
- c. vary the intensity of the background light
- d. change operators periodically

A.19.36

74. Which of the following X-ray generators would produce the narrowest cone of X-radiation?

- a. 10 MeV
- b. 15 MeV
- c. 25 MeV
- d. 1 MeV

A.23.3

75. A radiograph is taken at a voltage of 500 kV. If the voltage is increased with a resultant increase in the energy of radiation, while all other conditions remain the same:

- a. the graininess of the film will increase significantly if a high-speed film is used
- b. the graininess of the film will decrease significantly if a low-speed film is used
- c. the graininess of the film will increase significantly if a Class I film is used
- d. there will be little significant change in the graininess of the film

A.16.22

76. A radiograph of a steel weldment is made using a 15 MeV betatron. When the radiograph is developed, there is an overall film mottling. A possible cause for such mottling is:

a. incorrect exposure time

b. excessive object-to-film distance

c. failure to use a lead screen during exposure

d. excessive exposure to ultraviolet rays

A.23.7
77. A basic difference between a radiograph and a fluoroscopic image is:

a. the fluoroscopic image is more sensitive

b. the fluoroscopic image is a positive whereas the radiograph is a negative transparency

c. the fluoroscopic image is brighter

d. there is no basic difference between the two

A.24.20
78. Which of the following factors will not materially influence the image density of a radiograph?

a. the type of film used

b. the size of the film

c. the total amount of radiation emitted by the X-ray or gamma ray source

d. the intensifying action of the screen

A.20.3
79. A 1 000 kVp X-ray machine used in conjunction with a lead foil screen has an approximate practical thickness limit of:

a. 38 mm (1.5 in.) of steel or its equivalent

b. 76 mm (3 in.) of steel or its equivalent

c. 127 mm (5 in.) of steel or its equivalent

d. 41 cm (16 in.) of steel or its equivalent

F.13
80. Because of geometrical factors such as source size, source-to-specimen distance, and specimen-to-film distance, there can be a lack of perfect sharpness at the edges of indications. The unsharpness caused by geometrical factors may be referred to as the:

a. astigmatic effect

b. penumbral shadow

c. focus variation

d. none of the above

A.20.8
81. Two factors which greatly affect the suitability of the target material in an X-ray tube are:

a. tensile strength and yield strength

b. melting point and magnetic strength

c. electrical resistance and tensile strength

d. atomic number and melting point

F.9
82. The reason the exposure time must be increased by a factor of four when the source-to-film distance is doubled is that:

a. the intensity of radiation decreases at an exponential rate when the source-to-film distance is increased

b. the quality of radiation is inversely proportional to the square root of the distance from the source to the film

c. the intensity of radiation is inversely proportional to the square of the distance from the source to the film

d. the scattered radiation effect is greater as the source-to-film distance increases

A.20.10; D.28; F.25-26
83. The most important factor for determining the amount of X-ray absorption of a specimen is the:

a. thickness of the specimen

b. density of the specimen

c. atomic number of the material

d. Young's modulus of the material

F.26-28
84. The approximate radiographic equivalent factors for steel and copper at 220 kV are 1.0 and 1.4 respectively. If it is desirable to radiograph a 13 mm (0.5 in.) plate of copper, what thickness of steel would require about the same exposure characteristics?

a. 18 mm (0.7 in.) of steel

b. 6 mm (0.35 in.) of steel

c. 36 mm (1.4 in.) of steel

d. 25 mm (1 in.) of steel

F.27
85. Which of the following technique variables is most commonly used to adjust subject contrast?

a. source-to-film distance

b. milliamperage

c. kilovoltage

d. focal point size

E.6-68; F.30
86. Films that are left between lead screens too long in a high-temperature and high-humidity atmosphere may:

a. show increased speed but decreased quality characteristics

b. become fogged

c. become mottled

d. show tree-shaped light areas in the finished radiograph

A.20.28

Other Nonfilm Devices

87. In the past, several companies have designed TV cameras with large faceplates and phosphors that directly convert the received X-rays to electron scanning-beam variations. The thickness of the glass faceplate is recognized to prevent use at lower kilovoltage applications, but use at higher kilovoltages has never gained acceptance either, compared with other techniques. Which of the following is *not* correct for this type of system?

a. the quantum energy losses associated with converting the X-rays to electrical signals is improved over other systems by a factor of as much as 500 times

b. in comparison to systems using image orthicons with screens or with image intensifier system, the image presented is noisier

c. the extreme simplicity of this system and need for few controls or adjustments makes maintenance easier than other types of systems utilizing intermediate conversion

d. the extreme sensitivity of this system allows display of 2 percent penetrimeters over the range of 40-300 kVp

A.19.26-45

Solid-State Detectors

88. The obtainable counting speed using a scintillation counter is limited fundamentally by the:

a. energy level of the incident radiation

b. intensity of the incident radiation

c. afterglow of the phosphor

d. spatial distribution of the incident quanta

H.120
89. The scintillations (light photons) emitted by a radiation detection phosphor are converted to electrical pulses by:

a. a photomultiplier tube

b. an ionization chamber

c. a selenium photoelectric cell

d. a light pulse amplifier

H.250

Gaseous Ionization Detectors

90. One desirable property for a gas to be used in an ionization detector is a:

a. low saturation potential at which recombination of positive ions with electrons becomes negligible

b. low ionization potential

c. density approximately equivalent to the density of the chamber walls

d. density equivalent to that of air at standard temperature and pressure

A.16.2
91. The greatest problem which arises in the routine use of a pocket dosimeter is:

a. its relatively flat response to radiation of different energies

b. its inherently inconsistent sensitivity

c. electrical leakage that tends to discharge the electrometer and give false high readings

d. negative drift caused by changes in atmospheric conditions (temperature, humidity, etc.)

A.16.4
92. As a portable radiation survey instrument, the main disadvantage of a Geiger counter is its:

a. nonlinear response with changes in radiation energy

b. large size and delicate construction

c. poor sensitivity to low radiation levels

d. warm-up drift during the first few minutes of operation

A.16.6; E.5-24
93. Air-filled proportional counters are used extensively for monitoring:

A.16.6; E.5-24
- Instrumentation
94. An amplifier to be used in a survey instrument designed to measure high levels of radiation should have the following characteristics:

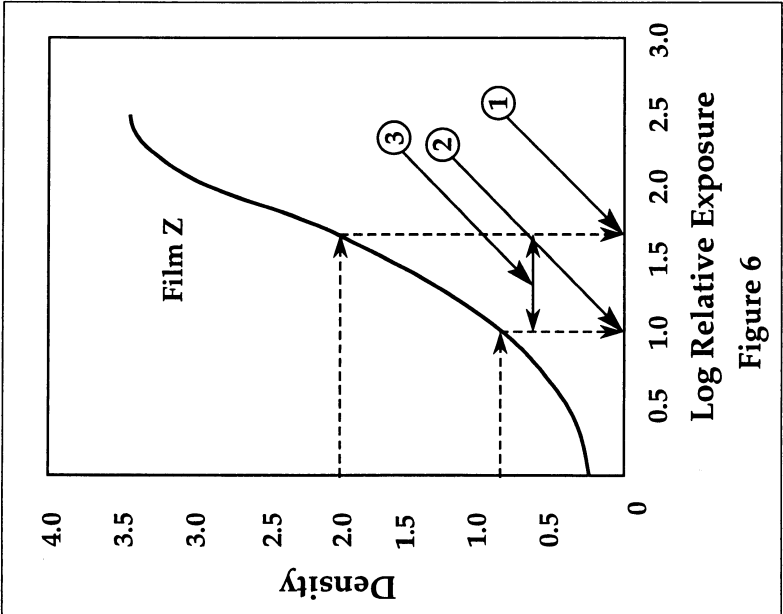
a. a fast rise time and a linear response

b. a fast rise time and an exponential response

c. a slow rise time and a linear response

d. a slow rise time and an exponential response

A.16.5
- Radiographic Testing Method, Level III
- 28
- 49



85. When using a constant potential X-ray source for fluoroscopic inspection, an optimum kilovoltage is said to exist for each material thickness. This optimum kilovoltage is:
- selected such that the part thickness to be X-rayed is 5 half-value layers
 - independent of the material area or curvature
 - selected as a function of the permissible X-ray tube current, with higher kilovoltage required for lower currents
 - selected on the basis of exposure time desired

A.19.46

TV and Optical Systems

86. A fluoroscopic system for the inspection of welds in 25 mm (1 in.) thick steel has the following features:
- X-ray source-to-image plane spacing of 43 cm (17 in.)
 - X-ray focal spot size of 4 mm (0.15 in.)
 - steel (weld) to image plane spacing of 76 mm (3 in.)
 - image plane length of 23 cm (9 in.) in vertical scan direction of TV system used to view image plane
 - TV system with 525 line scan, with image fully focused on image tube

During tests, it is found that this fluoroscopic system does very poorly in resolving wire penetrameters and imperfections of less than 0.89 mm (0.035 in.) when they are oriented parallel to the horizontal scan lines of the TV. Assuming that the image screen, optical system, and TV frequency response are capable of much better resolution than this, which of the following will increase the resolution of the system *the most*?

- increase the TV scan rate to 1029 lines, with an appropriate increase in frequency response
- increase the X-ray source-to-image plane spacing to 51 cm (20 in.)
- decrease the steel weld-to-image plane spacing to 51 mm (2 in.)
- change to an X-ray source having a 1 mm (0.3 in.) focal spot

A.19.2-6

Fluoroscopic Systems

84. Fluoroscopic screens of zinc cadmium sulfide find occasional use in industrial applications. These screens normally are not subject to wear or deterioration from exposure to long term X-rays. Which one of the following *will* severely degrade this type of screen?
- cleaning of the screen with grain alcohol solvent
 - prolonged storage in a low-humidity environment will cause the crystal to hydrolyze
 - exposure to ultraviolet radiation sources
 - contamination with nickel as little as one part per million will create severe afterglow problems

A.16.15-16

87. The quantitative measure of film blackening is referred to as:
- definition
 - photographic density
 - film contrast
 - radiographic contrast

A.20.31

88. A curve that relates density with the logarithm of exposure or of relative exposure is called:
- a sensitivity curve
 - a density-exposure curve
 - an H&D curve
 - X-ray intensity curve

A.20.32

89. Subject contrast is affected by:
- thickness differences in specimen
 - radiation quality
 - scattered radiation
 - all of the above

A.20.34

90. Which of the following instruments would exhibit the best sensitivity and most likely be used to detect small leaks in a radiation barrier?

- a film badge
- a fountain pen type of ionization chamber
- a Geiger counter
- a dosimeter

A.26.5

91. At voltages above 400 kV, the use of lead to provide protection may present serious problems. If this is a serious problem, which of the following materials would most likely be used as a substitute?

- aluminum
- concrete
- steel
- boron

F.143

92. A qualitative term often used to indicate the size of the smallest detail that can be seen in a radiograph is:

- radiographic sensitivity
- radiographic definition
- radiographic contrast
- subject contrast

A.20.34

93. The slope (steepness) of a characteristic curve is a measure of:

- subject contrast
- radiographic definition
- radiographic contrast
- film contrast

F.124

94. A special radiographic method requiring two radiographs taken during separate exposures from two different positions to give the visual impression of a three-dimensional display when viewed in an optical device simultaneously is called:

- fluoroscopy
- xeroradiography
- stereoradiography
- parallel radiography

A.20.47-48

95. The depth of a discontinuity can be estimated by making two exposures on a single film from two different positions of the X-ray tube. The depth of the discontinuity is computed from the shift in the shadow of the discontinuity with respect to the images of fixed markers on the front and back of the specimen. The method is called:

- stereoradiography
- xeroradiography
- fluoroscopy
- the parallax method of depth location

A.20.46-48; F.107

96. Constant agitation of the developer during the development process by means of mechanical stirrers or circulating pumps may:

- speed the developing cycle
- help replenish the developer
- cause undesirable, preferential flow of developer along certain paths
- cause reticulation

F.84

97. The activity of the fixer diminishes after being used for a period of time because the:

- active ingredients evaporate
- active ingredients are absorbed by the radiograph
- fixer solution accumulates soluble silver salts
- active ingredients settle to the bottom of the tank

A.21.8

Radiographic Testing Method, Level II

98. In processing radiographs, the hourly flow of water in the wash tank should be:
- a. 2-3 times the volume of the tank
 - b. 4-8 times the volume of the tank
 - c. at least 151 L (40 gal) per hour
 - d. varied continuously in proportion to the number of radiographs being developed
- A.21.8**
99. A zinc cadmium sulfide fluorescent screen that is continually exposed to bright daylight, sunlight, or other sources of ultraviolet radiation will:
- a. need to be recharged to regain its original fluorescence
 - b. become discolored and lose some of its brilliance
 - c. require a higher kilovoltage of the X-ray generator to produce a satisfactory image
 - d. all of the above
- A.16.15-16**
100. Increasing the X-ray or gamma ray energy will:
- a. significantly decrease the average gradient of a characteristic curve
 - b. significantly increase the average gradient of a characteristic curve
 - c. increase the slope of a characteristic curve
 - d. have little effect on the shape of a characteristic curve
- A.16.20**
101. As the development time increases:
- a. the characteristic curve grows steeper and moves to the left
 - b. the characteristic curve grows steeper and moves to the right
 - c. the characteristic curve remains the same in shape but moves to the left
 - d. there is little effect on the characteristic curve
- A.16.21**
102. A distinctive characteristic of high-voltage radiography is that:
- a. it results in comparatively high subject contrast
 - b. it results in comparatively high radiographic contrast
 - c. it is applicable to comparatively thick or highly absorbing specimens
 - d. all of the above are distinctive characteristics of high-voltage radiography
- A.23.1**
103. Lead screens are used for almost all exposures when using:
- a. the fluoroscopic technique
 - b. low-voltage radiography
 - c. high-voltage radiography
 - d. xeroradiography
- A.23.7**
104. Which of the following glasses would most likely be used as an X-ray barrier window on fluoroscopic equipment?
- a. Pyrex™
 - b. lead glass
 - c. optical glass
 - d. barium oxide glass
- A.19.13**
105. The maximum practical speed of scanning a test object for conventional fluoroscopic inspection has been estimated to be about:
- a. 18 cm (7 in.) per s
 - b. 25 mm (1 in.) per s
 - c. 30 cm (12 in.) per s
 - d. 76 mm (3 in.) per s
- A.19.25**
106. When other operating conditions are held constant, a change in tube current causes a change in radiation intensity emitted from an X-ray tube, the intensity being *approximately* proportional to tube current. What is the primary factor that prevents this from being *exactly* proportional?
- a. the voltage and voltage waveform of an X-ray machine transformer varies with load
 - b. wavelength changes are not exactly proportional
 - c. current cannot be changed at a linear rate
 - d. scatter radiation does not vary at a proportional rate
- A.20.3**
107. When viewing a radiograph, an image of the back of the cassette superimposed on the image of the specimen is noted. This is most likely due to:
- a. undercut
 - b. overexposure
 - c. the X-ray intensity was too high
 - d. backscatter
- A.20.21**

Radiographic Testing Method, Level III

71. Radiation output, also known as dosage rate or characteristic intensity, is usually expressed as effective output in what unit per curie?
- a. RHM
 - b. R/hr
 - c. rms
 - d. mR/h
- A.15.6; G.110**
72. Co-60 emits gamma rays of:
- a. 1.17 and 1.33 MeV
 - b. 0.66 MeV
 - c. 1.09 and 1.29 MeV
 - d. 1.36 and 2.75 MeV
- A.15.13**
73. The principal gamma rays emitted by Ir-192 are:
- a. 0.66, 0.84, and 0.91 MeV
 - b. 0.31, 0.47, and 0.60 MeV
 - c. 0.08, 0.05, and 0.66 MeV
 - d. 0.15, 1.12, and 0.18 MeV
- A.15.13**
74. Which of the following is an advantage of radiography with gamma rays as compared to X-rays?
- a. simplicity of apparatus
 - b. compactness of the radiation source
 - c. independence from outside power
 - d. all of the above
- F.14**
75. For a particular radioisotope, source strength is proportional to which of the following?
- a. mass of source
 - b. physical size
 - c. atomic weight
 - d. number of curies
- A.13.13**
76. Which of the following is true for a smaller isotope source of higher specific activity?
- a. suffers less from self-absorption of its own gamma radiation
 - b. less geometric unsharpness in the radiograph
 - c. allows shorter source-to-film distances
 - d. all of the above
- F.15**
77. gamma ray sources emit which of the following?
- a. broad continuous spectrum of wavelengths
 - b. limited wavelengths between 0.010 and 4 MeV
 - c. one or more discrete wavelengths
 - d. both a and b
- F.14**
78. Of the isotopes listed below, which occurs as the result of splitting an atom in a nuclear fission reactor?
- a. Co-60
 - b. Cs-137
 - c. Ir-192
 - d. Tm-170
- A.15.9**
- Film Principles and Properties**
79. Caution should be exercised to avoid removing film too rapidly from cartons, exposure holders, or cassettes. This would help to eliminate objectionable circular or tree-like black marks caused by:
- a. crimps
 - b. reticulation
 - c. static electricity
 - d. scratches
- F.77**
80. Extra-fine grain and high-contrast film used to obtain the highest quality from high-voltage X-ray equipment or for light metals is:
- a. Class I
 - b. Class II
 - c. Class III
 - d. Class IV
- A.20.29**
81. The agent that actually exposes a photographic grain (film) is:
- a. gamma and/or X-ray quantum
 - b. alpha particles
 - c. electrons
 - d. protons
- F.35**
82. Which of the following is governed by the distance travelled by the scattered electrons through the emulsion and consequently depends on the energy of the impinging radiations?
- a. geometric unsharpness
 - b. inherent unsharpness
 - c. radiographic contrast
 - d. effective graininess
- A.15.33-34**

60. When the high-voltage transformer is connected directly to the X-ray tube, the arrangement is called a:

- a. full rectified unit
- b. linear accelerator unit
- c. self-rectified unit
- d. tank-type unit

A.14.5

61. In X-ray equipment design, shielding placement and the angle of the coverage of the X-ray beam is *not* a function of:

- a. target angle
- b. filament
- c. X-ray tube port size
- d. geometry of the focal spot

E.3-11

62. A high-vacuum environment for X-ray tube elements is necessary for which of the following?

- a. to prevent oxidation of the electrode materials
- b. to permit ready passage of the electron beam without ionization of gas within the tube
- c. to provide electrical insulation between the electrodes
- d. all of the above

E.3-5

63. Which of the following is the major factor affecting the duty cycle of X-ray equipment?

- a. kV rating of equipment
- b. thickness of specimen
- c. rate of anode cooling
- d. size of focal spot

E.3-11

64. Two factors that limit the electric power that can be absorbed by X-ray tubes are the cooling system used for the anode and:

- a. tube grounding
- b. geometrical size of the focal spot
- c. a high screen effect
- d. the vacuum between cathode and anode

A.14.29

65. The efficiency of X-ray production is given by the following expression: $E = 1.4 \times 10^{-7} ZV$. Given a target of tungsten-coated copper and a tube voltage of 300 kV, determine the percent efficiency where E is in percent.

<i>Element</i>	<i>Z</i>
a. 8.8% hydrogen	1
b. 3.11% aluminum	13
c. 0.31% copper	29
d. 1.22% tungsten	74

B.94

Radioisotope Sources

66. Because it is frequently supplied as a water-soluble compound, which of the following is considered to have an additional radiological hazard potential associated with it?

- a. Co-60
- b. Tm-170
- c. Ir-192
- d. Cs-137

E.3-16

67. Tm-170 emits which of the following gamma ray energies?

- a. 1.33 and 1.17 MeV
- b. 0.084 and 0.052 MeV
- c. 0.310 and 0.470 MeV
- d. 0.110 and 0.150 MeV

E.3-15

68. Which one of the following radioisotope sources would be the *best* choice for radiography of a steel specimen 9.5 mm (0.375 in.) thick from an energy standpoint?

- a. Co-60
- b. Tm-170
- c. Ir-192
- d. Cf-252

E.3-15

69. The half-life is a useful characteristic of a radioisotope. After 6 half-lives, the amount of decaying atoms is reduced to approximately what percent of the amount at the beginning?

- a. 2 percent
- b. 3 percent
- c. 6 percent
- d. 1 percent

D.22

70. Generally, sources of high specific activity are more desirable because they have _____ self-absorption.

- a. higher
- b. the same
- c. lower
- d. no

G.110

113. A 250 kVp X-ray machine used in conjunction with a lead foil screen has an approximate practical thickness limit of:

- a. 38 mm (1.5 in.) of steel or its equivalent
- b. 51 mm (2 in.) of steel or its equivalent
- c. 15 cm (6 in.) of steel or its equivalent
- d. 19 cm (7.5 in.) of steel or its equivalent

F.13

114. The degree of concentration of the radioactive material in a gamma ray source is referred to as the:

- a. specific activity of the source
- b. quality of the source
- c. atomic weight of the source
- d. half-life of the source

F.15

115. In million-volt radiography, filtration at the tube:

- a. increases the generation of short wavelength X-rays
- b. decreases the generation of short wavelength X-rays
- c. improves the radiographic quality by decreasing scatter radiation
- d. offers no improvement in radiographic quality

F.45

116. Film selection for an X-ray exposure depends on:

- a. the thickness of the part
- b. the material of the specimen
- c. the voltage range of the X-ray machine
- d. all of the above

A.20.31

117. While using an X-ray tube for radiography, the operator wants to increase the radiation intensity. To do so, the:

- a. kilovoltage should be lowered
- b. tube current should be increased
- c. test specimen should be moved further from the film
- d. tube current should be decreased

F.24

118. Lead screens are put in direct contact with the film to:

- a. increase the photographic action on the film
- b. absorb the longer wavelength scattered radiation
- c. intensify the photographic effect of the primary more than the scattered radiation
- d. do all of the above

A.20.25

Radiographic Testing Method, Level II

119. Because of geometrical factors such as source size, source-to-specimen distance, and specimen-to-film distance, there can be a lack of perfect sharpness at the edges of indications. The unsharpness caused by these factors may be called the:

- a. astigmatic effect
- b. penumbral shadow
- c. focus variation
- d. none of the above

A.20.8

120. The main purpose of the X-ray generator controls on the equipment is to:

- a. maintain the direction and width of the X-ray beam
- b. enable the operator to obtain the intensity, quality, and duration of exposure desired
- c. allow the operator to adjust Film Focal Distance remotely
- d. change alternating current to increase X-ray intensity

A.14.2

121. Fluoroscopic screens, as mounted and used, are easily damaged by which of the following?

- a. washing with a soft cotton cloth
- b. exposure to ultraviolet radiation or sunlight
- c. poor handling
- d. X-radiation

A.16.15

122. When X-rays, gamma rays, light, or electrons strike the photographic emulsion, a change takes place in the silver halide crystals. This change is called:

- a. photographic density
- b. photographic sensitivity
- c. latent image
- d. characteristic curve

A.16.18

123. If 3.7 GBq (1 Ci) of Ir-192 produces a dose rate of 5 900 mR/h at 0.3 m (1 ft), how many mR will 3 700 GBq (10 Ci) produce at the same distance?

- a. 590
- b. 590 000
- c. 59
- d. 59 000

A.20.15; E.5-6

124. With respect to quality, what three factors must be considered in selecting a source-to-film distance?

- a. source activity, type of film, type of screens
- b. source activity, size of film, thickness of material
- c. source size, source activity, specimen-to-film distance
- d. source size, specimen thickness, geometric unsharpness

E.6-25; F.52-61

125. On a radiograph of a pipe weld, there is a very light irregularly-shaped small image in the weld. This image would most likely be due to the presence of:

- a. porosity
- b. slag inclusion
- c. tungsten inclusion
- d. inadequate buildup

A.25.10

126. A larger physical size source may produce an equivalent quality radiograph if:

- a. the source-to-film distance is increased
- b. more backing lead is used
- c. a faster film is used
- d. exposure time is decreased

F.19-22

127. A light image of a backing "B" on a processed radiograph is probably caused by:

- a. excessive density
- b. backscatter
- c. kilovoltage set too low
- d. poor film handling

C.E94

128. Co-59 becomes Co-60 when it is placed in a nuclear reactor where it captures:

- a. an electron
- b. a neutron
- c. a proton
- d. contamination

A.15.14; D.17

129. When a faster speed film is substituted for a slower one to improve the economics of the exposure, which of the following conditions occur?

- a. the film must receive special processing
- b. the definition will improve
- c. the image resolution will be reduced
- d. none of the above will be experienced

D.94; E.4-9

49. Flash X-ray tubes are usually designed to produce electrons for acceleration by which one of the following methods?

- a. hot emission
- b. field emission
- c. changing magnetic field of a transformer primary
- d. high-frequency electrical waves

F.12

Target Materials and Characteristics

50. Tungsten is the preferred target material for X-ray tubes used in industrial X-ray machines because it provides a double advantage. One of the advantages is that:

- a. the efficiency of the tungsten material in the production of X-rays is proportional to its atomic number
- b. it has a low melting point
- c. the efficiency of the tungsten material in the production of X-rays is inversely proportional to its atomic number
- d. it has a high curie point

F.9

51. Gold and platinum are also used in X-ray tubes for radiography, but targets made of these metals must:

- a. be more effectively heated than targets made of tungsten
- b. be more effectively cooled than targets made of tungsten
- c. be able to withstand increasing pressure
- d. have low thermal conductivity

G.108

52. Tungsten is the most commonly used target material in X-ray tubes. Which one of the following materials, although not common, is commercially used for industrial X-ray tube targets?

- a. gold
- b. beryllium
- c. molybdenum
- d. germanium

C.108

53. The efficiency of the target material in the production of X-rays is proportional to:

- a. kilovoltage
- b. spacing of electrodes
- c. atomic number
- d. Avogadro's number

F.9

54. In choosing a suitable metal for a target material, the principal properties to be considered are all but which one of the following?

- a. high atomic number
- b. high melting point
- c. high thermal conductivity
- d. high vapor pressure

A.14.3

55. When X-rays are not emitted with the same intensity in all directions from the focal spot, this is called:

- a. screen effect
- b. angle of emergence
- c. heel effect
- d. astigmatism

A.14.29

Equipment Design Considerations

56. An anode in which the target is located at the bottom of an opening or "pocket" is frequently used in industrial X-ray tubes for improving the distribution of the high voltage field. This type of anode is called:

- a. rotating anode
- b. hot anode
- c. hooded anode
- d. line-focus anode

A.14.34; H.22

57. High-voltage electrostatic generators of the Van de Graaff type are typically insulated with:

- a. trichloroethylene
- b. nitrogen/carbon dioxide
- c. argon/oxygen
- d. trichloroethane

A.14.17

58. The most significant consideration of X-ray tubes, based on the low efficiency of X-ray production, is:

- a. target angle
- b. focal spot size
- c. accelerating voltage
- d. heat dissipation

A.14.3

59. In choosing a suitable metal for an X-ray tube target, which of the following is not a property that is normally considered?

- a. atomic number
- b. melting point
- c. mass attenuation coefficient
- d. thermal conductivity

A.14.3

Radiographic Testing Method, Level III

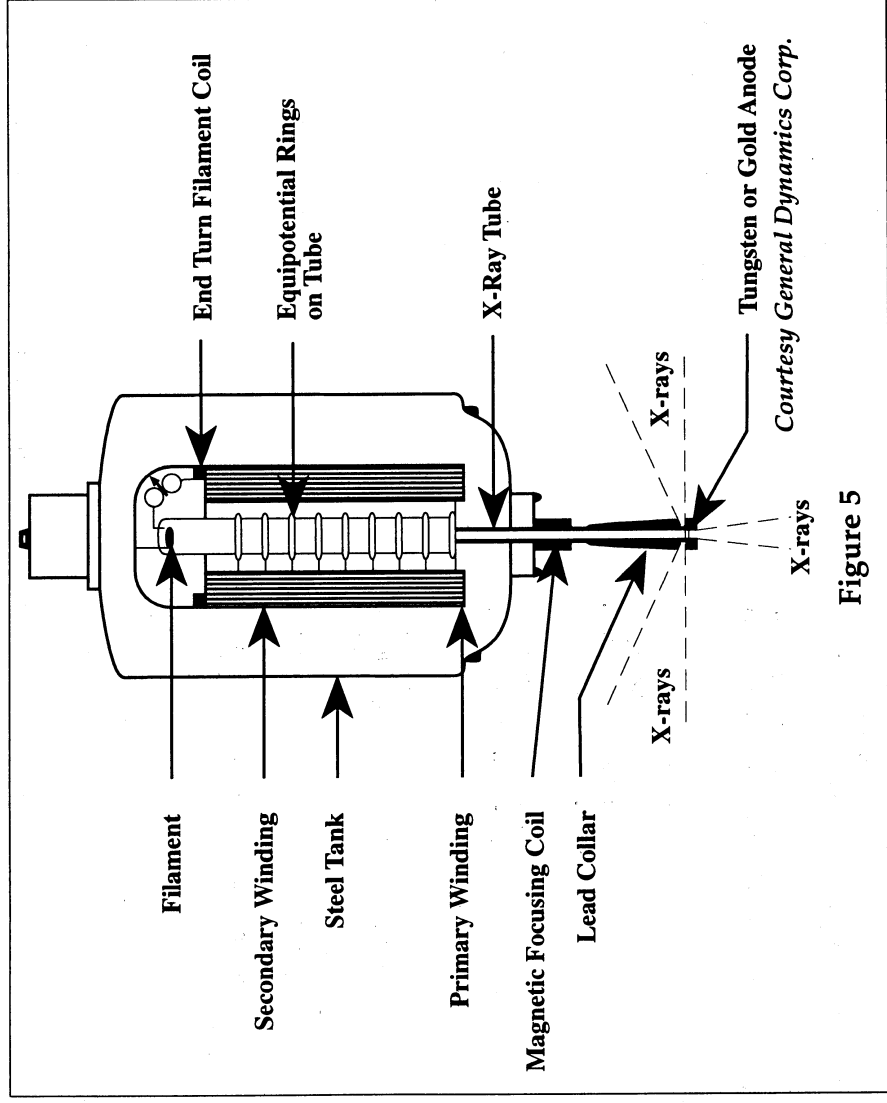


Figure 5

Electron Accelerating Methods

46. In a betatron, electrons are accelerated by which of the following?

a. field emission
b. changing magnetic field of an AC electromagnet
c. high-frequency electrical wave
d. accelerating magnets

F.12

47. In a linear accelerator, the electrons are accelerated by which of the following?

a. high-frequency electrical wave
b. accelerating magnets
c. neutron bombardment
d. changing magnetic fields of an AC electromagnet

F.13

48. In a high-voltage generator of the Van de Graaff type, by which method are the particles accelerated?

a. accelerating magnets
b. high-frequency electrical waves
c. static negative charges
d. none of the above

F.13

43. The type of X-ray generator illustrated in Figure 5 is

a:

a. electrostatic generator
b. resonant transformer generator
c. linear accelerator
d. tank type generator

E.3-9

44. The betatron accelerates electrons in a circular path by:

a. radio frequency energy
b. magnetic induction
c. use of a nonconducting charging belt
d. resonating the high voltage to the frequency of the AC power

A.14.18; E.3-10

45. What method is used for generation of X-rays in the multimillion volt range?

a. electrostatic generator
b. betatron
c. linear accelerator
d. all of the above

F.12-13

130. For a given change in the radiation exposure, film contrast is the inherent ability to show:

a. a difference in density
b. no graininess
c. graininess
d. no appreciable change in density

E.4-5

131. The ability of a material to block or partially block the passage of X-rays and gamma rays is called:

a. penetration
b. absorption
c. absorption
d. latitude

F.26

132. Source size, specimen thickness, and source-to-specimen distance are the three factors that determine the:

a. density of the radiograph
b. exposure of the radiograph
c. film size
d. unsharpness recorded on the radiograph

E.6-25

133. The range of specimen thicknesses that can be adequately recorded on the radiograph is called:

a. sensitivity of the radiograph
b. latitude of the radiograph
c. accuracy of the radiograph
d. intensity of the source

A.23.4

134. Approximately how long would it take for a 370 GBq (10 Ci) Co-60 source to decay to 93 GBq (2.5 Ci)?

a. 5.3 days
b. 5.3 years
c. 10.6 years
d. none of the above

A.15.14; D.81; E.3-15

135. The "photoelectric" effect involves:

a. the visible electromagnetic spectrum
b. an electric camera
c. complete absorption of a photon
d. all of the above

D.26

136. Radiographic undercutting is caused by:

a. side scatter
b. poor geometry
c. lead screens
d. free electrons

D.89

137. The developer solution is:

a. acid
b. alkaline
c. saline
d. colloidal

F.141

138. A general rule governing the application of the geometric principles of shadow formation states that the:

a. X-rays should proceed from as large a focal spot as other considerations will allow
b. distance between the radiation source and the material examined should be as small as practical
c. film should be as far as possible from the object being radiographed
d. central ray should be as nearly perpendicular to the film as possible to preserve spatial relationships

A.20.7

139. The half-life of radioactive Cs-137 is nearest to:

a. 36 days
b. 6 years
c. 30 years
d. 526 days

A.15.9; D.81

140. The slope of the H&D curve of a radiographic film is called:

a. speed
b. latitude
c. gamma or gradient
d. density

F.125

141. The projected area of the target of an X-ray tube is called:

a. focal spot
b. focus
c. effective focal spot
d. geometric unsharpness

F.10

142. The correct equation for determining geometric unsharpness U_g is:

a. $U_g = \frac{f}{td}$ where
 d = source-to-object distance
b. $f = U_g = \frac{t}{d}$
 t = object-to-film distance
c. $U_g = \frac{dt}{f}$
 f = size of radiation source
d. $U_g = \frac{ft}{d}$

F.21

143. An exposure technique is established to obtain a 2.0 density using type "D" film and automatic processing at 27 °C (81 °F). In order to obtain comparable results using manual processing at 20 °C (68 °F) and 5-minute development time, it would be necessary for the original exposure time to be:

- a. reduced by approximately 30 percent
- b. increased by approximately 99 percent
- c. increased by approximately 30 percent
- d. reduced by approximately 99 percent

A.19.3

Note: The two characteristic curves of Figures 1 and 2 on pages 35 and 36 may be used in solving this problem.

Note: Use Figure 4 in order to answer questions 31-35

31. The meter that typically shows the beam current is:

- a. B
- b. D
- c. F
- d. C

32. The filament transformer is shown by:

- a. G
- b. I
- c. C
- d. E

33. The autotransformer is shown by:

- a. G
- b. I
- c. C
- d. E

34. The kilovoltage selector is shown by:

- a. F
- b. A
- c. D
- d. H

35. The timer is shown by:

- a. J
- b. H
- c. F
- d. I

36. The beam current in an X-ray tube is critically dependent upon:

- a. target material
- b. filament voltage
- c. distance between anode and cathode
- d. all of the above

37. The focal spot should be as small as conditions permit, in order to obtain:

- a. the sharpest possible definition
- b. the minimum size of the unit
- c. the maximum energy density
- d. none of the above

Sources of Electrons

38. The focusing cup of the cathode in an X-ray tube acts as an electrostatic lens, determining the size of the electron beam by:

- a. capturing stray electrons emitted by the filament
- b. limiting the maximum amperage of the filament current
- c. reducing the negative charge on the glass walls of the tube caused by secondary electrons scattered by the target
- d. controlling the electric field between the anode and the cathode

A.14.27

39. The most common source of electrons in high-vacuum X-ray tubes is:

- a. reflection from the anode
- b. the heated cathode
- c. the heated anode
- d. the tungsten target

A.14.3; F.9

40. The most common technique for releasing electrons in gas X-ray tubes is:

- a. reflection from the target in the anode of the tube
- b. increasing the kilovoltage
- c. positive ion bombardment of the cold cathode
- d. heating a filament

A.14.3

41. The most commonly used cathode type for industrial X-ray tubes is:

- a. cold cathode
- b. hot cathode
- c. rotating disk cathode
- d. solid rectangular cathode

A.14.8

42. The design and spacing of the electrode and the degree of vacuum are such that no flow of electrical charge between the cathode and anode is possible until the:

- a. filament is heated
- b. high-voltage waveform reached 180°
- c. circulation system is operated
- d. none of the above

F.9

27. The rad (radiation absorbed dose) is defined as the amount of:

a. radiation energy absorbed by 1 cm³ of material

b. radiation energy absorbed by 1 g of material

c. radiation energy representing the absorption of 10 μJ (100 ergs) of energy per cm³ of material

d. radiation energy representing the absorption of 10 μJ (100 ergs) of energy per g of material

D.51

28. The need for the concept of the rem (roentgen equivalent man) arises from the fact that:

- a. there is no way to accurately measure the production of ions in air

b. the roentgen represents such a small amount of energy as to be cumbersome in calculations used in radiography applications

c. the amount of energy required to produce an ion pair in animal tissue differs from the amount of energy required to produce an ion pair in air

d. the roentgen incorporates the effect of neutron and electron radiation in air that it does not incorporate the effect of X-rays in animal tissue

D.51

29. The rem is defined as the quantity of radiation:

a. of any type which, when absorbed by any animal tissue, produces a physiological effect equivalent to that produced by the absorption of 258 μC/kg (1 roentgen) of X- or gamma rays

b. absorbed by 1 cm³ of animal tissue

c. necessary to absorb 0.1 μJ (1 erg) of energy by 1 g of animal tissue

d. absorbed by one gram of animal tissue

D.51

Generators and Tubes as an Integrated System

30. X-ray generators built to provide X-rays at very low energy levels are used in special areas in nondestructive testing. The single section X-ray tubes in these low voltage units are usually built with thin windows of what material to permit soft X-rays to emerge from the vacuum envelope?

- a. beryllium

b. germanium

c. selenium

d. Pyrex™ glass

A.14.12

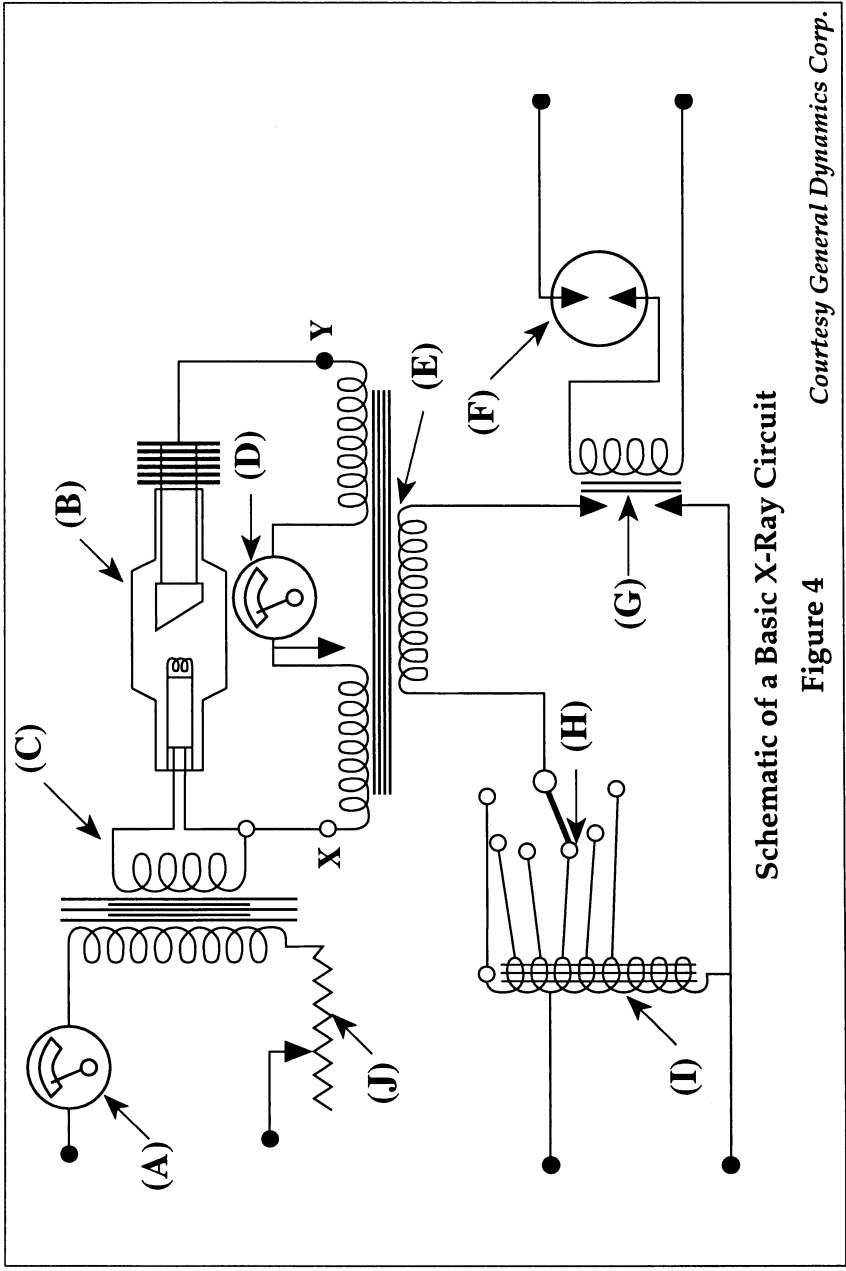
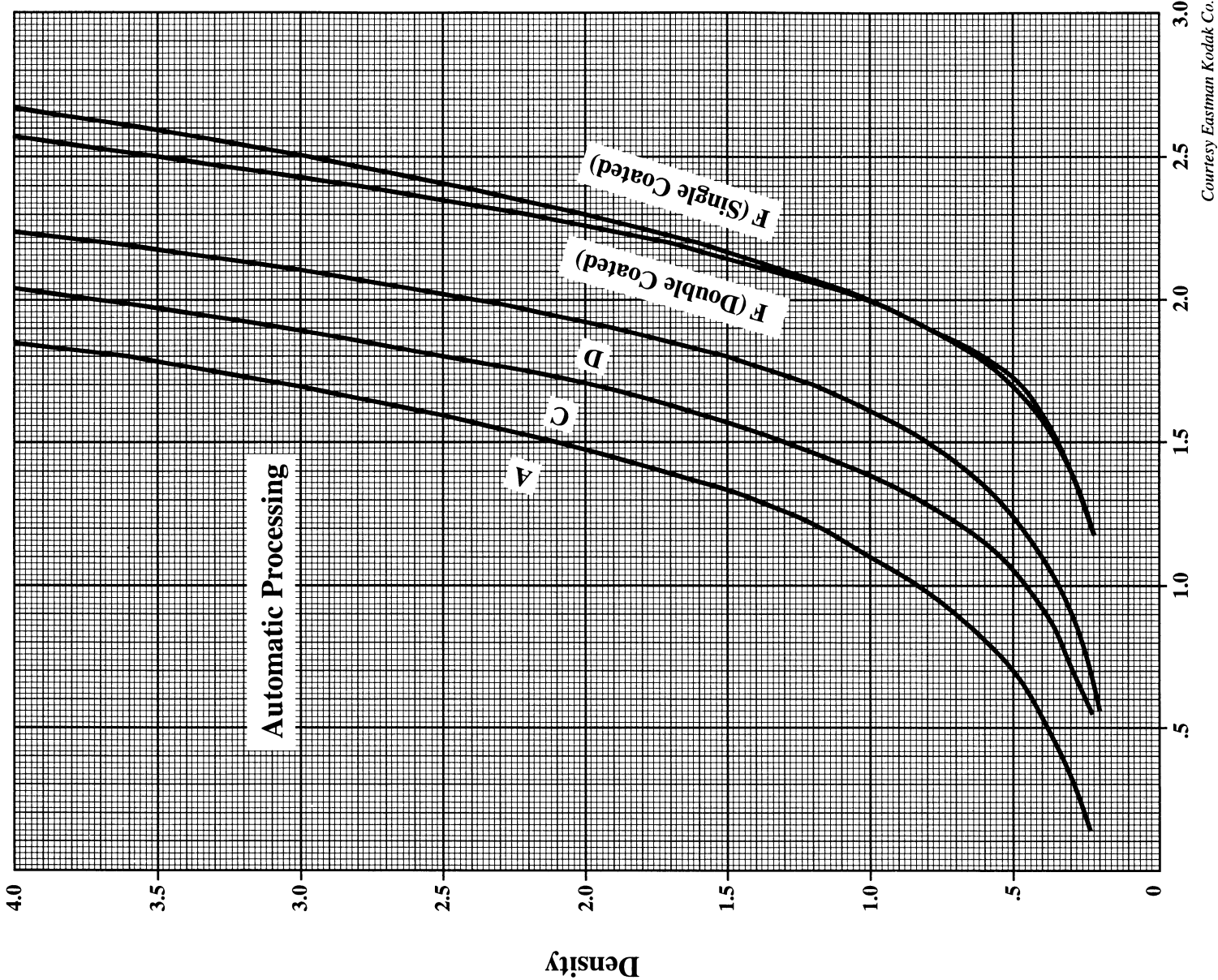


Figure 4 Courtesy General Dynamics Corp.

Figure 1

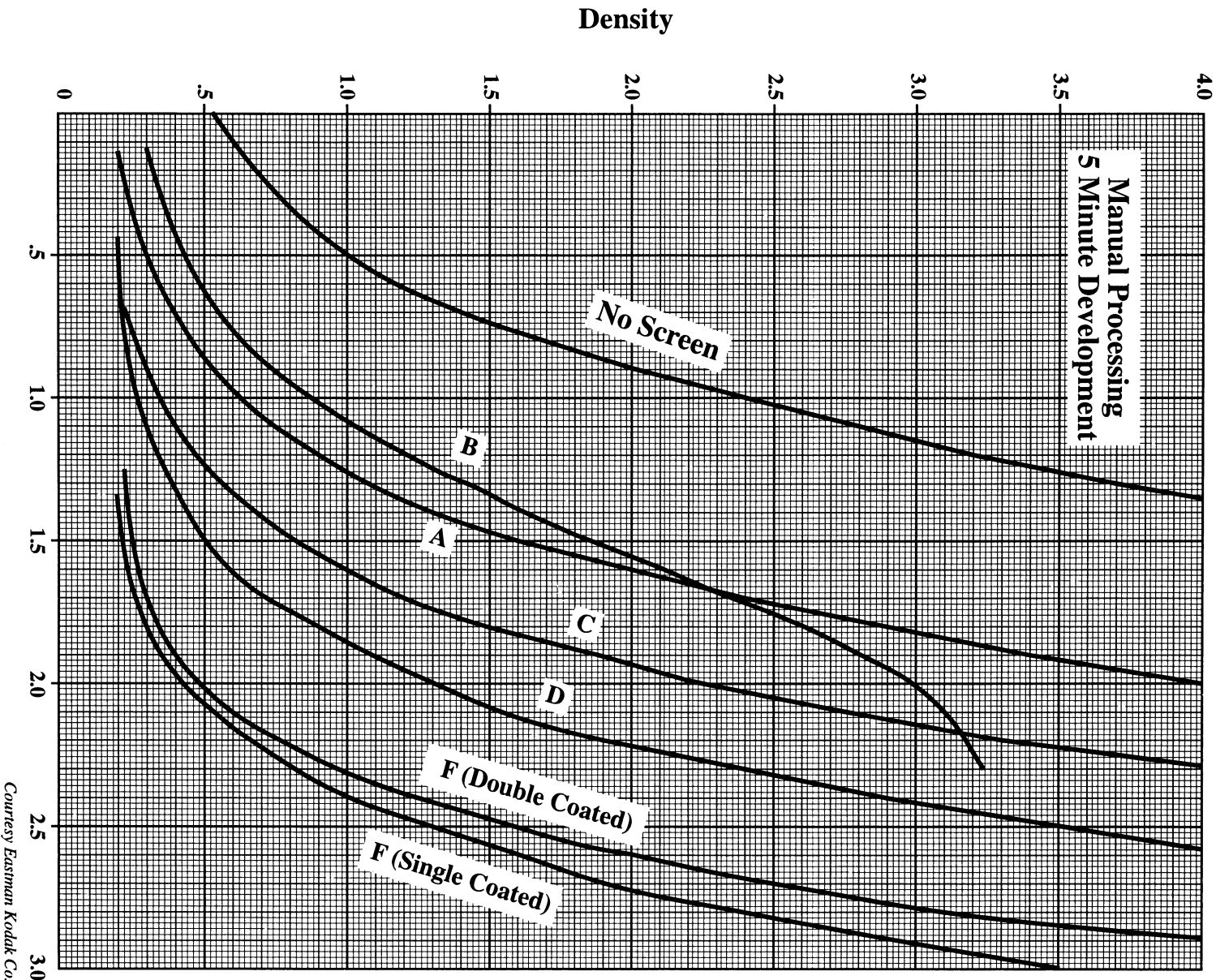
Exposure: 200 kVp Lead Screens
Developer: 81 °F with 11 Minute Dry-to-Dry Cycle



Courtesy Eastman Kodak Co.

Log Relative Exposure

Figure 2
Exposure: 200 kVp Lead Screens
Developer: 5 Minutes at 68 °F



18. Radiation particles and photons lose their energy primarily through which of the following processes?

- a. radioactive decay
- b. ionization
- c. atomic absorption
- d. thermionic emission

D.25

Imaging by Film

19. According to accepted theory, the spots at which the latent image is localized on the emulsion are local concentrations of:

- a. silver sulfide
- b. silver bromide
- c. silver iodide
- d. silver nitrate

F.135

Imaging by Fluorescent Materials

20. The Bunsen-Roscoe reciprocity law, which states that the developed film density depends only on the product of radiation intensity times exposure duration, fails for:

- a. direct gamma ray exposures
- b. fluorescent screen exposures
- c. lead screen exposures
- d. direct X-ray exposures

F.129

21. In photofluorography where a fluoroscopic screen is used for radiographic imaging, it is important to choose a screen that has a visible light emission that is relatively high at the X-ray wavelengths to be used and that:

- a. matches the wavelength sensitivity of the human eye
- b. has a minimum decay time
- c. can be viewed directly without the use of leaded glass or mirrors
- d. matches the wavelength sensitivity of the particular image detector being used

A.16,14-17

22. When comparing fluorescent intensifying screens with lead foil screens, their primary advantage is:

- a. improved image resolution
- b. markedly increased exposure times
- c. markedly decreased exposure times
- d. relative insensitivity to scattered radiation

C.130

23. Fluoroscopy of a specimen using a 140 kVp 10 mA X-ray source results in an intensity of 66R per minute at the screen surface. Of the screen brightness values and approximate screen colors below (for the stated radiation level), which represents the most desirable screen for use in direct viewing fluoroscopy?

- a. Brightness – 9.8 lx (0.91 ftc); color – green
- b. Brightness – 8.5 lx (0.79 ftc); color – yellow
- c. Brightness – 7 lx (0.65 ftc); color – blue
- d. Brightness – 4.6 lx (0.43 ftc); color – green

A.19,9, 19-13

Imaging by Electronic Devices

24. Unlike other commercially available X-ray intensification systems, the direct X-ray pick-up tube:

- a. has quantum energy losses exceeding a factor of 500
- b. has extremely low sensitivity
- c. converts the X-ray image directly into an electrical signal
- d. converts X-rays to light and light to electrical signals

A.19,40

25. A fundamental difficulty of fluorescent imaging is the relatively low brightness level of the images. Electronic fluoroscopy can help to eliminate this problem by all but which one of the following?

- a. using X-ray tubes of lower operating potential
- b. using an image tube
- c. using X-ray tubes of greater effective loading
- d. using the X-ray television system

A.19,37

Radiometry

26. The roentgen is defined as the amount of:

- a. radiation emitted by 1 Ci of Ir-192 at a distance of 1 m (3.3 ft)
- b. X- or gamma radiation of 0.1 μ J (1 erg) of energy in 1 g of dry air at standard temperature and pressure
- c. X- or gamma radiation that will produce 1 electrostatic unit of charge in 1 cm^3 of dry air at standard temperature and pressure
- d. X- or gamma radiation absorbed by 1 cm^3 of water at 0 °C (32 °F) and 101 kPa (760 mm of Hg)

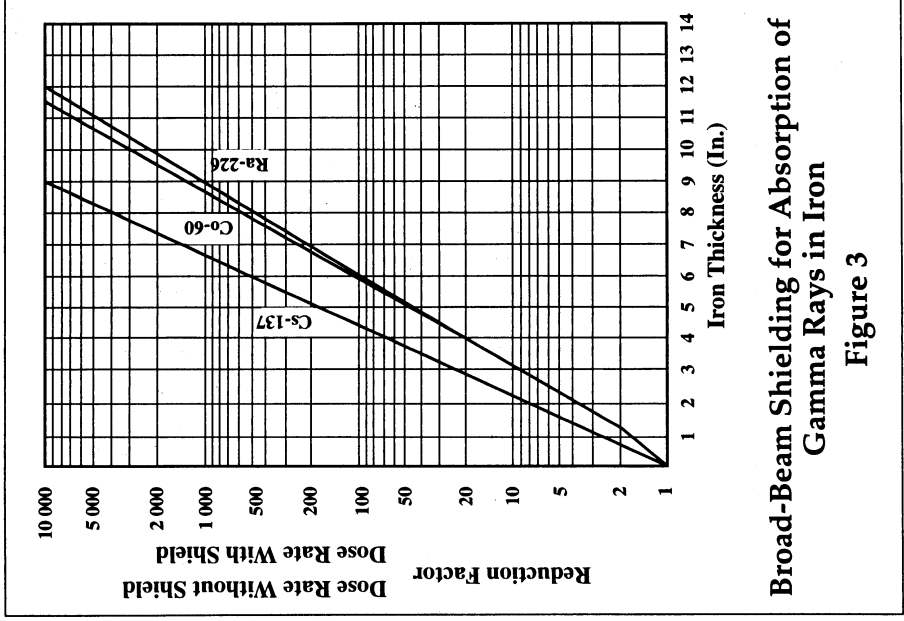
D.51

Radiographic Testing Method, Level III

9. A Co-60 source has an intensity of 1 600 mR/h at a distance of 1.8 m (6 ft). Workers need to be at that distance from the source but should receive only 2 mR/h approximately. How much steel shielding is required? (Figure 3 may be used to determine the correct answer.)

- a. 71 mm (2.8 in.)
b. 18 mm (6.9 in.)
c. 24 cm (9.3 in.)
d. cannot be determined from data given

D.35



10. Pair production occurs when electromagnetic radiation consists of photons in what energy range?

- a. 0.025 to 0.1 MeV
b. 30 to 50 MeV
c. 1.02 or greater MeV
d. 0.1 to 1.0 MeV

D.26

11. In the photoelectric interaction process:

- a. electrons are emitted
b. characteristic X-rays are emitted
c. secondary photons are emitted
d. all of the above

E.2-14

12. The Compton interaction process is characterized by:

- a. absence of secondary radiation
b. no transfer of energy upon interaction
c. production of an electron-positron pair
d. partial transfer of energy upon collision

E.2-14

13. The “build-up” factor in radiation attenuation is the:

- a. ratio of broad-beam intensity to narrow-beam intensity at a particular absorber thickness
b. absorption coefficient divided by the half-value layer
c. ratio I/I_0 in $I = I_0 e^{-\mu x}$
d. percentage of radiation absorbed in unit thickness of material

A.15.37

14. The major component of scatter is the low-energy electromagnetic radiation produced by photons weakened in the:

- a. photoelectric process
b. Compton process
c. pair production process
d. ionization process

E.2-16

15. The increase in radiation passing through matter due to scatter in the forward direction is called:

- a. build-up
b. reduction factor
c. backscatter
d. bremsstrahlung

D.33; E.2-16

16. High-energy photons of 1.02 MeV or greater typically interact with matter by which one of the following?

- a. photoelectric process
b. Compton process
c. pair production process
d. thermionic process

D.27; E.2-14

17. In which of the following processes will some energy of the interacting photon be used to dislodge the electron from its orbit and the remainder used to give the electron kinetic energy?

- a. photoelectric process
b. Compton process
c. pair production process
d. ionization process

D.26

Level II Answers

Radiographic Testing Method

1. b
2. d
3. c
4. a
5. c
6. a
7. d
8. c
9. a
10. c
11. c
12. c
13. a
14. d
15. b
16. c
17. b
18. d
19. d
20. c
21. b
22. d
23. b
24. c
25. d
26. b
27. a
28. c
29. b
30. d
31. a
32. b
33. c
34. a
35. b
36. d
37. c
38. a
39. b
40. c
41. b
42. b
43. b
44. a
45. c
46. a
47. a
48. d
49. c
50. c
51. a
52. d
53. b
54. b
55. c
56. d
57. b
58. a
59. d
60. b
61. b
62. a
63. d
64. b
65. c
66. d
67. d
68. b
69. b
70. d
71. a
72. b
73. d
74. c
75. d
76. c
77. b
78. b
79. c
80. b
81. d
82. c
83. c
84. a
85. c
86. b
87. b
88. c
89. d
90. c
91. b
92. a
93. d
94. c
95. d
96. c
97. c
98. b
99. b
100. d
101. a
102. c
103. c
104. b
105. d
106. a
107. d
108. a
109. c
110. c
111. b
112. c
113. b
114. a
115. d
116. d
117. b
118. d
119. b
120. b
121. b
122. c
123. d
124. d
125. c
126. a
127. b
128. b
129. c
130. a
131. c
132. d
133. b
134. c
135. c
136. a
137. b
138. d
139. c
140. c
141. c
142. d
143. b

Level III Questions

Radiographic Testing Method

Nature of Penetrating Radiation

Interaction between Penetrating Radiation and Matter

1. Atoms of the same element that have different numbers of neutrons are called _____ of the element.

a. molecules

b. isotopes

c. isotones

d. isomers

D.6
2. The number of positive charges on the nucleus of an atom equals the:

a. number of neutrons

b. atomic number

c. number of photons

d. atomic weight

D.6
3. Unlike beta and alpha particles, neutrons have no:

a. charge

b. mass

c. spin

d. half-life

A.13.3
4. Radiation scattering increases as:

a. the energy of the incident radiation decreases

b. the size of the radiation field increases

c. the angle of scatter decreases

d. all of the above

A.26.10
5. It has been found from experiment that a homogeneous radiation beam of intensity I passing through a thickness of material Δx undergoes a decrease in intensity ΔI . This can be expressed by the equation, $\Delta I = -\mu \Delta x$, where μ is a constant of proportionality. This expresses which of the following phenomena?

a. photoelectric effect

b. Compton scattering

c. absorption

d. half-value thickness

B.103
6. The number of ion pairs produced per centimeter of track in air is called:

a. secondary ionization

b. total ionization

c. specific ionization

d. roentgen

D.25
7. Which of the following particles or rays have the highest ionizing effect in air?

a. alpha particles

b. beta particles

c. neutrons

d. gamma and X-rays

D.25
8. The intensity of a monoenergetic radiation after passing through a material may be calculated by the formula $I = I_0 e^{-\mu x}$. This formula does not take into account:

a. linear absorption

b. buildup

c. half-value layer thickness

d. attenuation

D.30