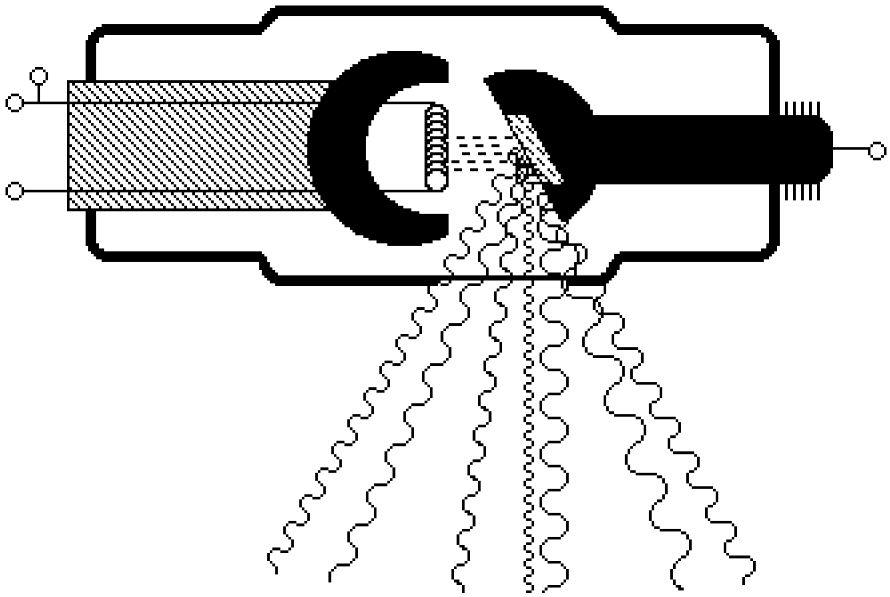
Practical Radiation Physics

Fourteenth Edition



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Practical Radiation Physics

A Preclinical Program for Dental Students

Fourteenth Edition

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Exercise 1

Part I

The Effect of Developer and Fixer on Film Emulsion

NOTE: The following procedures may be carried out under ordinary lighting.

1. Ia (i) Note and record (or make an illustration of) the position of the embossed dot on the non-tube side of the film (Figure 1-1).

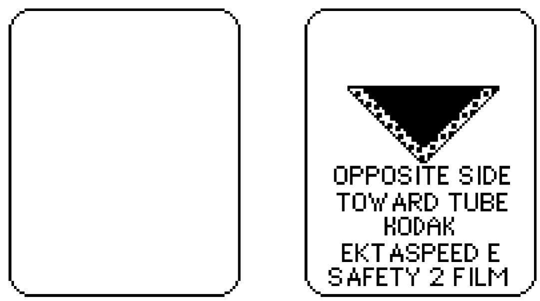


Figure 1-1. The film packet, front and back, on which to locate the dot.

1. Ia (ii) Note and record the position of the embossed dot on the tube side of the film (Figure 1-1). (The convex side of the raised dot should always face the radiation source.)

1. Ia (iii) Open the film packet; note the position of the lead to the tube side of the film (Figure 1-2).

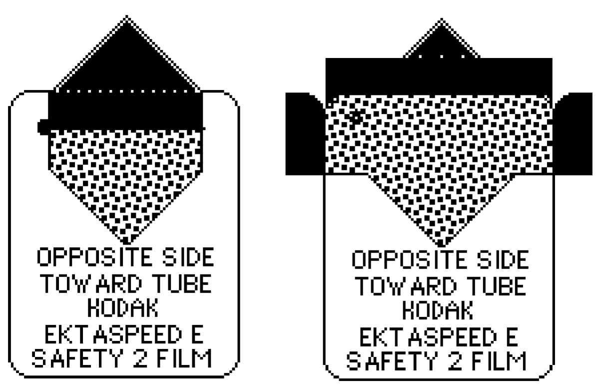


Figure 1-2. Location of the lead foil in the film packet.

1. Ia (iv) Note and place a check by the appearance of the herringbone pattern on the lead foil (Figure 1-3). Mount the unexposed, unprocessed film, one per partner.

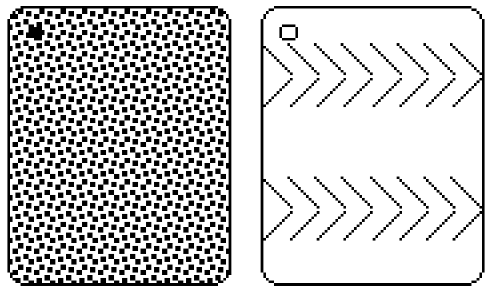


Figure 1-3. “Herringbone” patterns found in film packets.

1. Ib Expose another film to light and process. Note and record what happens to the film.

1. Ic Expose another film to light. Do not develop, but fix, then wash and dry. Note and record what happens to the film.

NOTE: The instructor will process the film in the automatic processor, but put it through the fixer, wash, and dryer only.

Part II

The Effect of Bending on Film Emulsion

1. II Take a film packet and crease it sharply in one or two places. Then place this film packet between your teeth and bite heavily on it in several places. Process the film under safelight conditions according to standard time-temperature recommendations. Process and record your observations.

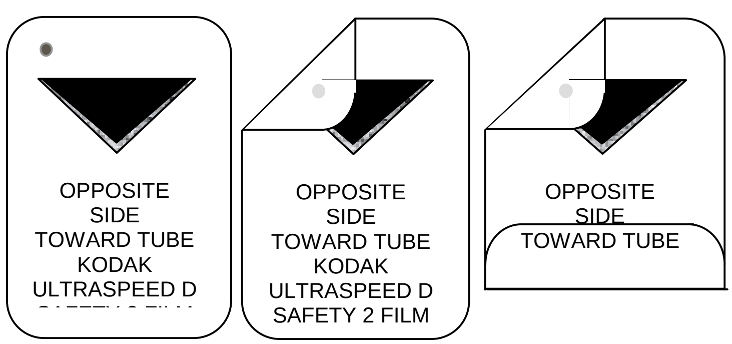


Figure 1-4. The film packet bent in two areas.

Part III

The Effect of the Lead Backing on the Radiographic Image

1. IIIa Place a film packet over some metal screening on top of a block of wax. Cover the film with a block of 0.3 cm lead and make the exposures shown below. (Figure 1-4)

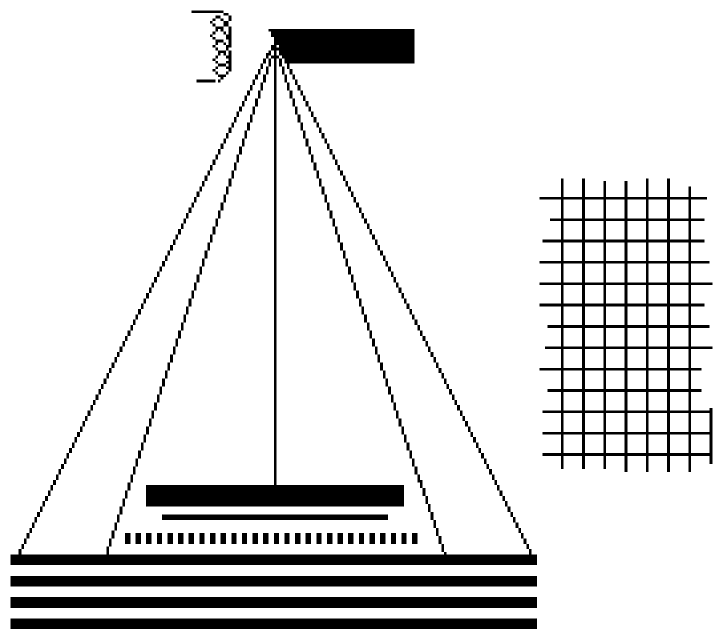


Figure 1-5. A schematic illustration of the set-up to demonstrate backscatter radiation.

PID	short round
milliamperage (mA)	10
kilovolt peak (kVp)	70
time	2 sec.
focal film distance (FFD)	8"

1. IIIb Using another film, but reversed so that the colored tab side of the packet faces towards the tube, make a second exposure using the same settings.

Process and mount the radiograph. Record your observations.

Part IV

The Effect of Emulsion Speed (ANSI Speed Group) on the Radiographic Image

1. IVa Make an exposure with ANSI Speed Group F film using the piece of mandible embedded in plastic (Figure 1-5).

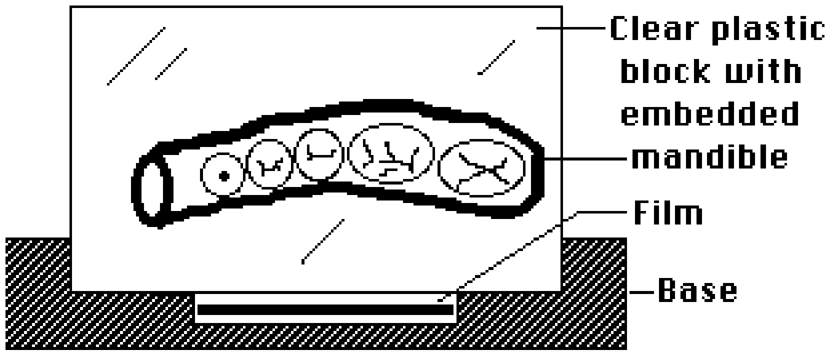


Figure 1-6. A piece of mandible embedded in clear plastic provides a tissue equivalent phantom for most exercises. The base, with the recess in the floor to hold number 2 size film is keyed to allow reproducible results.

Use the following settings:

mA	10
kVp	70
time	30 imp
FFD	16"

1. IVb Make a second exposure at the same settings using a new film, but reverse the film.

1. IVc Make a third exposure using ANSI Speed Group D film and the following settings:

mA	10
kVp	70
time (normal)	1 sec.
FFD (normal)	16"

NOTE: The exposure time for the Speed D film is approximately 2 times the exposure time with the Speed F film.

Questions

1. What happens to the film during developing? What is the action of developer?

2. What happens to the film during fixing? What is the action of fixer?

3. What is the effect of placing a film that had been exposed to light, but not to developer, into the fixing solution first?

4. What would be the effect of processing a film that had not been exposed to light or radiation?

5. What do you think the effect of prolonged fixing would be?

6. What is the effect of bending on the film emulsion?

7. Define definition. Which emulsion speed has the better definition, if any?

8. Define contrast. Is there any difference in contrast?

9. Are there any differences between the two emulsions?

10. What are the advantages and disadvantages of the two emulsions?

11. What conclusions do you draw from handling radiographs in regards to:

    (a) effect of natural lighting leaks or improper safelights?

    (b) care of handling processing solutions?

12. What is the effect on the radiographic image of reversing the film packet in the mouth?

13. What do you conclude to be the purpose of the lead foil backing?

Exercise 2

The Effect of Tube Kilovolt Peak (kVp) on Radiographic Density and Image Quality

Part I

2. I. (i) Place the lead mask provided (with three holes) and the marker (small hole indicates No. 1) on a film packet (Figure 3-1):

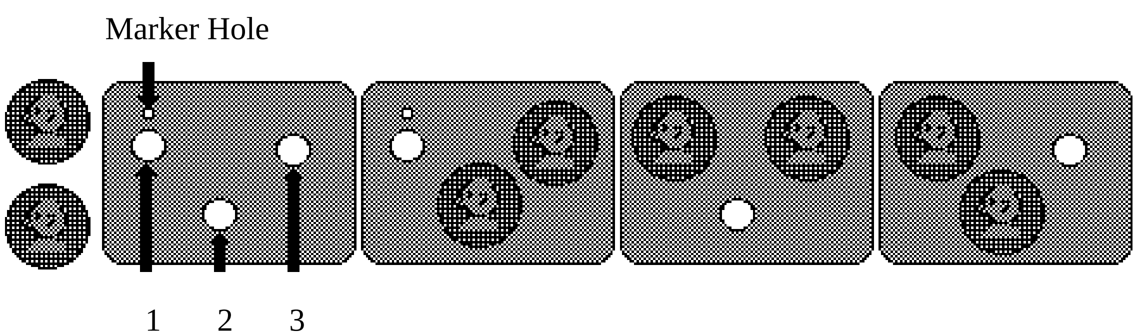


Figure 2-1. A Lead mask with three holes allows exposure of restricted parts of the film packet. Two coins are placed so that only one hole is exposed each time. The small hole allows correct identification of the holes.

After covering holes No. 2 and 3, expose through No. 1 with the following settings:

mA	10
kVp	50
time (exposure 0.125 x normal)	8 imp

2. I. (ii) With the same film, but holes No. 1 and 3 covered, expose through hole No. 2, with the following settings

mA	10
kVp	70
time (exposure 0.25 x normal)	8 imp

2. I (iii) With the same film, but holes No. 1 and 2 covered, expose through hole No. 3, with the following settings

mA	10
kVp	90
time (exposure 0.5 x normal)	8 imp

Process normally and mount. Record your observations of the effect on density as the voltage is varied.

Part II

2. IIa Place an aluminum step wedge on a film packet and expose it using the following factors and the appropriate marker (50 kVp) (Figure 2-2):

constant		variable	
mA	10	kVp	50
FFD	16"	imp	24

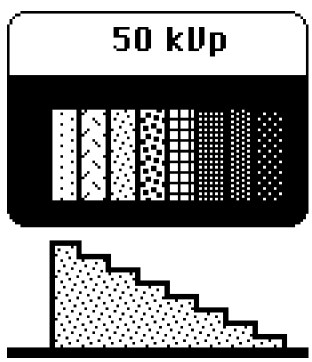


Figure 2-2. The effect of varying the tube voltage can be seen by placing an aluminum stepwedge over the film to be exposed. Films are identified using marked lead foil strips.

2. IIb Repeat using the same constants, changing only the variables and the marker (70 kVp):

constant		variable	
mA	10	kVp	70
FFD	16"	imp	24

2. IIc Repeat using the same constants, changing only the variables and the marker (90 kVp):

constant		variable	
mA	10	kVp	90
FFD	16"	imp	24

Process normally and mount. Record your observations of the effect of increasing the kilovoltage.

Part III

2. IIIa Repeat the exercise using a tooth with a small artificial cavity with the following settings and appropriate marker (50 kVp) (Figure 2-3):

constant		variable	
mA	10	kVp	50
FFD	16"	imp	36

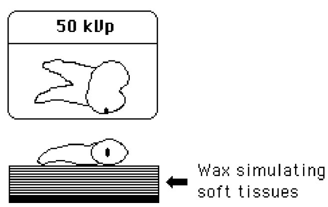


Figure 2-3. Use of a tooth with a small cavity reveals the clinical significance of altering the tube voltage.

2. IIIb Repeat using the same constants, changing only the variables and the marker (70 kVp):

constant		variable	
mA	10	kVp	70
FFD	16"	imp	18

2. IIIc Repeat using the same constants, changing only the variables and the marker (90 kVp):

constant variable

mA	10	kVp	90
FFD	16"	imp	8

Process normally and mount. Record your observations of the effect of decreasing the kilovoltage and increasing the exposure time.

Questions

1. How are the characteristics of the x-ray beam (i.e. quality and quantity) affected by increasing kVp?

2. Which kilovoltages result in short scale contrast (fewer shades from black to white)?

3. Which kilovoltages result in long scale contrast (more shades from black to white)?

4. What is the difference between the radiographic images of the tooth made at 50 kVp and 90 kVp?

5. Which kilovoltages give the least penetrability? The most penetrability?

6. Which kilovoltages result in images of best contrast (sharp crisp differences between shades of black, grey and white)?

7. Which kilovoltages result in images of least contrast?

8. List the advantages and disadvantages of high kilovoltage techniques and low kilovoltage techniques in oral and maxillofacial radiography. Give reasons to back up your statements.

Exercise 3

The Relationship of Milliamperage and Time to Radiographic Density

Part I

3. Ia (i) Place the lead mask provided (with two holes) and the one small hole marker over a number 2 size film. Cover hole No. 2 with the lead rectangle, and expose through hole No. 1 (Figure 3-1).

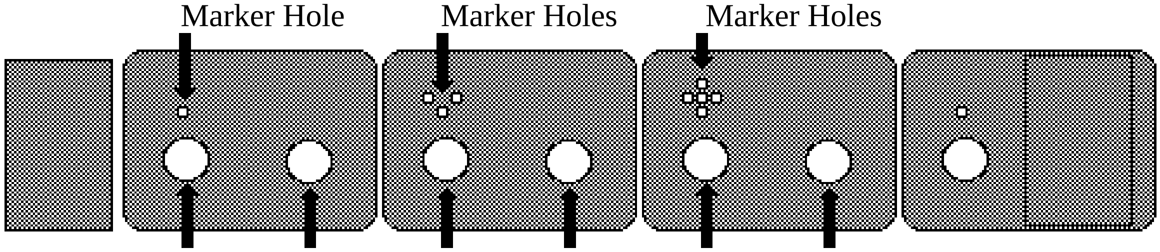


Figure 3-1. Place the lead mask with two holes and one marker hole over the film. Then cover first the one hole and marker hole, then the other, to make the required exposures.

Use the following settings:

mA	10
kVp	50
time (exposure 0.25 x normal)	8 imp

3. Ia (ii) With the same film, but hole and marker hole No. 1 covered, expose through hole No. 2, with the same settings except change to:

mA	15

Process normally and mount. Record your observations of the effect on density as the milliamperage is varied.

3. Ib (i) Place the lead mask provided (with two holes) and the three small marker holes over another number 2 size film. Cover hole No. 4 with the lead rectangle, and expose through hole No. 3 and the three marker holes. Use the following settings:

mA	10
kVp	50
time (exposure 0.5 x normal)	15 imp

3. Ib (ii) With the same film, but hole No. 3 and the three marker holes covered, expose through hole No. 4, with the same settings except:

mA	15

Process normally and mount. Record your observations of the effect on density as the milliamperage is varied.

Part II

3. II (i) Place the lead mask provided (with two holes) and the five small marker holes over another number 2 size film. Cover hole No. 6 with the lead rectangle, and expose through hole No. 5 and the five marker holes. Use the following settings:

Use the following settings:

mA	10
kVp	70
time	12 imp

3. II (i) With the same film, but hole No. 5 and the five marker holes covered, expose through hole No. 6, with the following settings:

mA	15
kVp	70
time (exposure 0.25 x normal)	8 imp

Process normally and mount. Record your observations of the effect on density as the milliamperage is varied, including which machine was used.

Questions

1. What is the effect of increasing milliamperage by 50% on radiographic density?

2. What is the effect of doubling time on radiographic density?
3. What is the relationship between milliamperage and density? Time and density?

4. How are the characteristics of the x-ray beam (i.e. quality and quantity) affected by changing mA? Time?

5. In each set of exposures, what was the mAs (i.e. the product of mA and time)?

6. How did the two exposures in parts IIa and IIb compare with respect to density?

7. What is the function (use in radiography) of the product of milliamperage and time?

Exercise 4

The Relationship of Focal-Film Distance (FFD) and Object Film Distance (OFD) to Beam Intensity, Image Definition and Production

Part I

The Relationship between Focal-Film Distance (FFD) and Beam Intensity

4. Ia (i) Place the lead mask provided (with two holes) and the one marker hole over a number 2 size film. Cover hole No. 2 with the lead rectangle, and expose through hole No. 1 and marker hole (Figure 4-1) using the following settings:

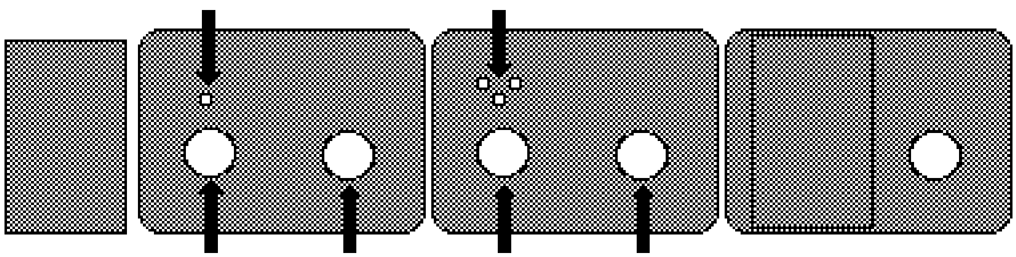


Figure 4-1. Place the lead mask with two holes and the one marker hole over the film. Then cover first the first hole and marker hole, then the other, to make the required exposures.

mA	10
kVp	70
time	3 imp
FFD	8 "

4. Ia (ii) With the same film, but hole No. 1 and marker hole No. 1 covered, expose through hole No. 2, with the same settings except change to:

FFD	16 "

Process normally and mount. Record your observations of the effect on density as the distance is increased.

4. Ib (i) Place the lead mask provided (with two holes) and the three marker holes over a number 2 size film. Cover hole No. 4 with the lead rectangle, and expose through hole No. 3 and marker holes (Figure 4-1 using the following settings:

mA	10

	kVp	70
	time	12 imp
	FFD	16 "

4. Ib (ii) With the same film, but hole No. 3 and marker holes covered, expose through hole No. 4, with the following changed settings

time	3 imp
FFD	8 "

Process normally and mount. Record your observations of the effect on density as the distance is increased.

Part II

The Effect of Focal-Film Distance (FFD) on Image Definition

4. IIa Place a film packet covered with the appropriate marker into a 5 cm plastic container with the base raised, then close the container and place a piece of wire mesh onto the lid, centered over the film packet. This will give an Object-Film Distance (OFD) of approximately 3 cm (Figure 4-2):

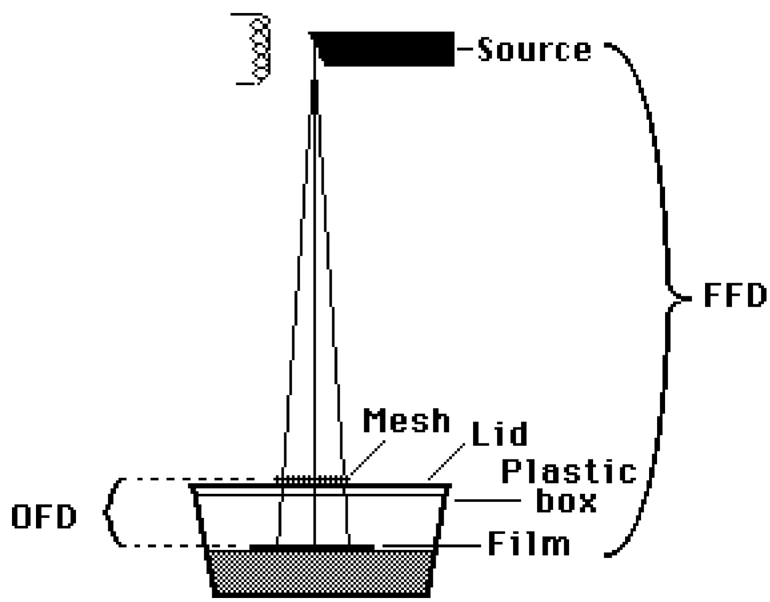


Figure 4-2. A plastic container with lid is used to increase the OFD when making a radiograph of the wire mesh. A clear plastic lid facilitates alignment of source, mesh, and film.

Expose the film using the following settings:

mA	10
kVp	90
FFD	8"
OFD	as per lid-base height
time	8 imp

4. IIb Repeat with a new film packet and marker using the wire mesh.

Expose the film using the following settings:

mA	10
kVp	90
FFD	16"
OFD	as per lid-base height
time	30 imp

Part III

The Effect of Focal-Film Distance (FFD) and Object-Film Distance (OFD) on Image Production

4. IIIa Place an extracted tooth and the marker directly onto a number 2 size film. Expose the film using the following settings:

mA	10
kVp	70
time	15 imp
FFD	16 "

4. IIIb Repeat using a new film. Expose the film using the following changed settings:

time	4 imp
FFD	8 "

4. IIIc Place a film packet covered with the appropriate marker into a 5 cm plastic container with the base raised, then close the container and place a tooth onto the lid, centered over the film packet (Figure 4-1). This will give an OFD of approximately 3 cm. Expose the film using the following settings:

mA	10
kVp	70

time	4 imp
FFD	8 "

4. IIId Repeat using a new film. Expose the film using the following changed settings:

time	15 imp
FFD	16 "

Measure and record the size of the tooth.

Process normally and mount. Record your observations of the effect on image of the various changes in geometry.

Questions

1. What is the effect on density of increasing FFD? Estimate how great this effect is.

2. This is a manifestation of a constant relationship between distances and intensity that applies to electromagnetic radiations. Please state it.

3. What is its importance, clinically?

4. What FFD results in the sharpest image (i.e. the best definition)? Why?

5. What FFD results in an image with the least distortion and least magnification? Why?

6. Which radiographic image most nearly corresponds to the actual tooth measurements.

7. What are your conclusions about the clinical significance of FFD and OFD?

Exercise 5

Part I

The Emission of Scatter Radiation by Various Materials

5. (i) Set up the apparatus, with wood test material, as per the diagram (Figure 5-1), using a short PID. Place the appropriate marker, showing the test material and kVp, over the film. The distance from the test material to the film should be as short as possible. Place the film approximately 2 cm in from the front of the lead tunnel.

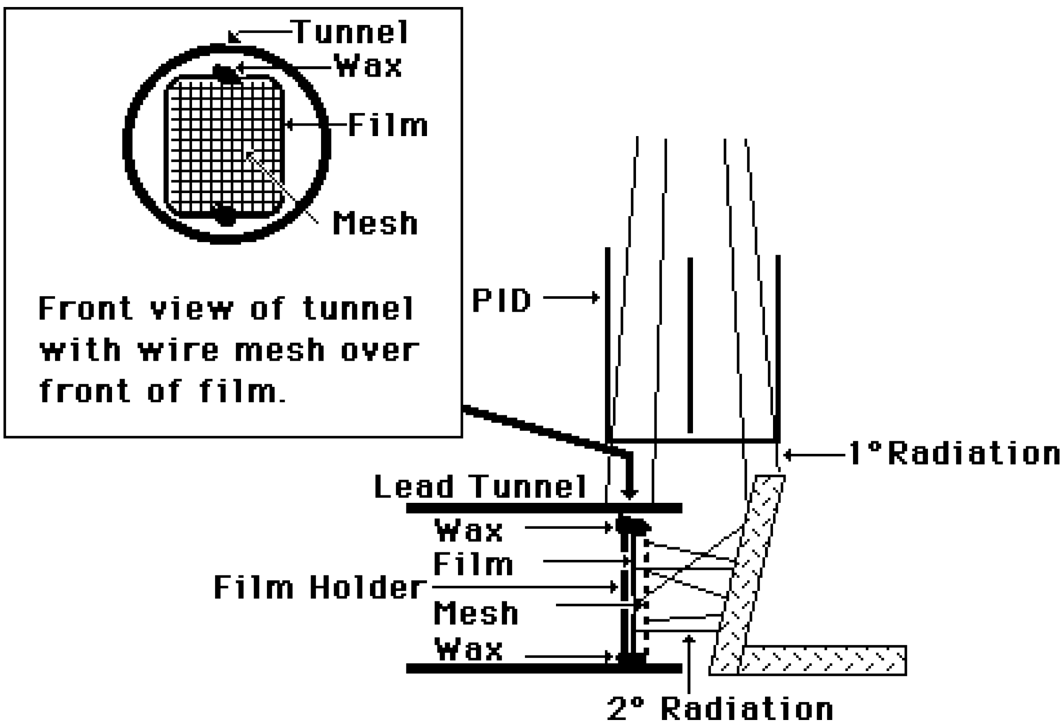


Figure 5-1. A schematic illustration of the set-up for demonstrating the production of secondary and scatter x radiation by the various materials.

Expose the film using the following settings:

mA	10
kVp	70
time	1 sec

5. (ii) Repeat the above, using a new film and kVp marker, and the following exposure factors:

mA	10
kVp	90
time	30 imp

5. (iii) Repeat both steps, using new films and markers, with wax test material and then lead test material, using the same exposure factors..

Process normally and mount. Record your observations of the production of secondary/scatter radiation by various materials at the selected kVp.

Questions

1. Compare the films and write up your report.

2. What is the only source of radiation reaching the film?

3. What material emits secondary radiation best?

4. What is the influence of kVp in producing secondary radiation?

5. What practical application would this exercise have in the practice of oral radiology?

A Demonstration of the 60-Cycle Nature of X-ray Production and the Accuracy of the Timing Mechanism

6. (i) Place 2 films in the 5" x 7" cassette provided. Place onto and center over the turntable of the modified portable record player (Figure 6-1).

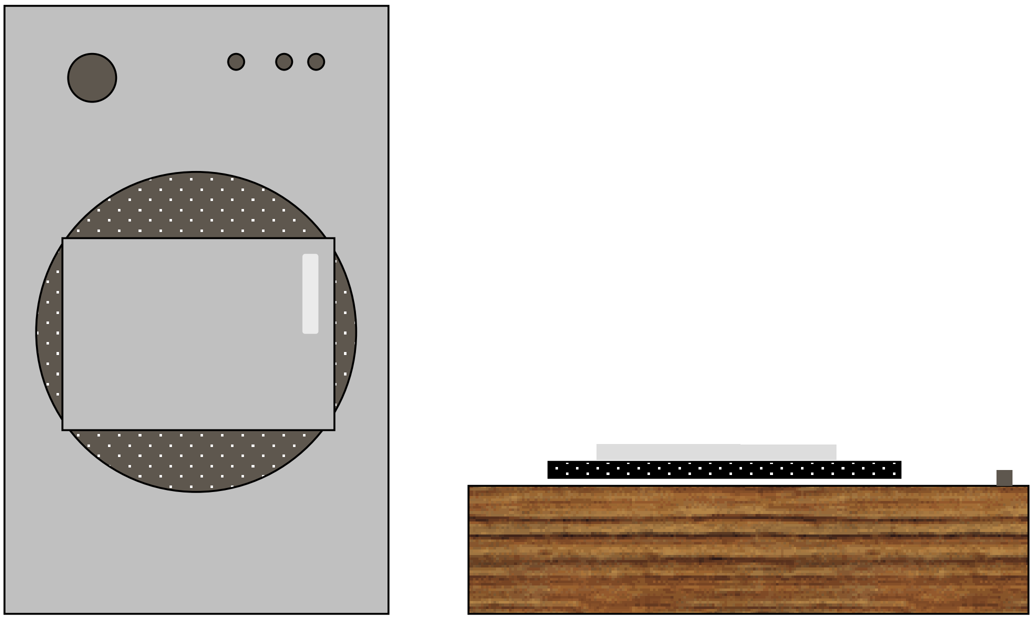
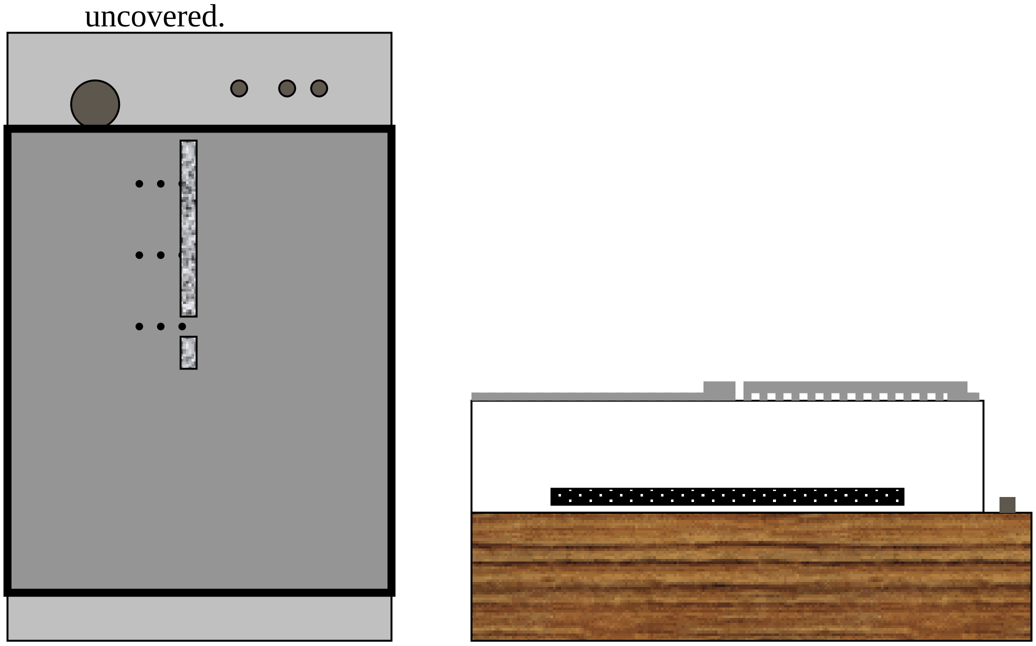
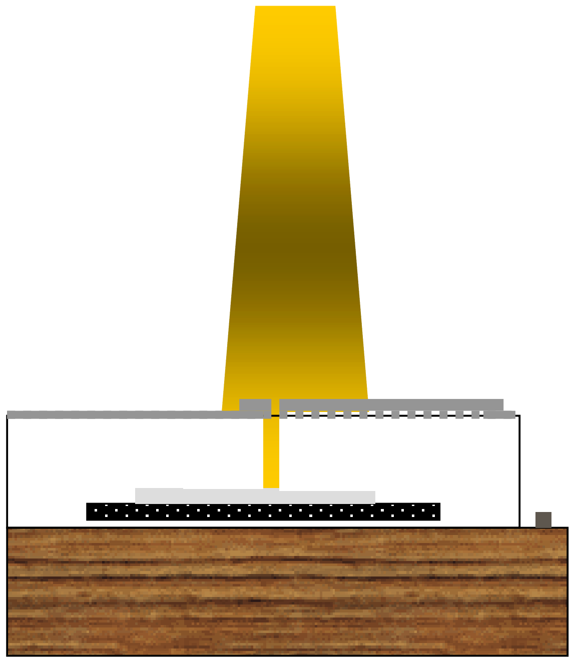


Figure 6-1. Use of a record player and cassette with film to demonstrate the 60-cycle nature of x-ray production and to check the accuracy of the x-ray timing mechanism.

(ii) Set the speed of the record player for 45 rpm. Close the lid, which has a leaded top and cover the small holes with lead so that only the first one is uncovered.



(iii) Turn on the machine, so that the turntable is spinning,



(iv) Prepare the x-ray unit for exposure using the following factors:

mA	15
kVp	70
FFD	16"

(v) Make the first exposure at 1 impulse and 45 rpm

(vi) Subsequently, after moving the blocker so that successive holes are uncovered, one for each exposure, while previous holes are recovered, make the following series of exposures, using the same kVp, mA and FFD as above.

second hole	4 imp	45 rpm
third hole	8 imp	45 rpm
fourth hole	12 imp	45 rpm
fifth hole	18 imp	33 rpm
sixth hole	36 imp	33 rpm
seventh hole	1 sec	33 rpm
eighth hole	1 sec*	33 rpm

Process the film normally. Record your observations of the nature of the exposure and the accuracy of the timer.

* The exposure for the eighth hole is a repeat of that for the seventh, to allow a check of reproducibility.

Questions

1. Why is there a series of black dots where the x rays passed through the hole?

2. How many spots should there be in each alternation of the cycle? Why?

3. How many in one second?

4. Is the density of each spot the same?

5. What is the significance of the finding in question 4?

6. Is the timer accurate?