MODULE 6

Radiographic exposures

Aim

To provide sufficient knowledge of exposure selection and manipulation, to enable accurate selection of exposures, in order to produce maximum information on the resultant radiographs.

Objectives

On completion of this module the student will

- Understand the effect each exposure factor has on the resultant radiograph.
- Be able to use this knowledge effectively.
- Be able to select the correct exposure factors required.
- Understand and use the **step system** of exposure calculation.
- Be able to manipulate exposure factors using the **step system**.
- Be able to establish and maintain a reliable exposure chart.
- Be able to modify an existing exposure chart.

Strictly speaking the term, "exposure" refers to the quantity of radiation to which the patient is exposed.

In practical radiography we tend to talk of "exposure" as the collective exposure factors, kV, mA and time, which together will produce the radiation exposure that will give the required penetration, density and contrast on the radiograph.

There are several other factors, which influence film quality, but here we will only consider kV, mA, time and FFD (SID).

kV

- Controls largely the **penetrating power** (better described as the quality of the beam), and to a lesser degree, the intensity of radiation and therefore film density and patient dose.
- Affects **contrast**. The higher the kV the lower the contrast. The lower the kV the higher the contrast.

mA

- Controls the **intensity** of radiation and therefore film density and patient dose. The higher the mA, the higher the film density and patient dose.

time

- Controls the **length of time** of radiation flow, and therefore film density and patient dose. The longer the exposure time the higher the film density and patient dose.

mAs

- The multiple of **mA and time** (in seconds).
- Many modern X-ray units are designed to use mAs rather than mA and time separately.

FFD (SID)

- The greater the distance an X-ray beam travels the less effective it will be, the less distance it travels the more effective it will be.
- Exposure compensation is therefore necessary with changes in FFD (SID).

For the radiographer it is important to set the correct exposure factors required to produce a high quality radiograph, which will give the maximum amount of information yet minimise the dose to the patient.

It is important to have systems in place that will help the radiographer to select and manipulate exposure factors effectively.

Exposure chart

Each X-ray unit should have a list of commonly used exposures for easy reference (see *Appendix B*, page 164). This list will, of course, be limited, but will at least provide a guide.

Methods of recording exposures

- Written chart.
- Notebook.
- Computerised "chart" within the X-ray unit.

Here we will deal with:

- Establishing and modifying an exposure chart.
- Manipulating exposure factors using the step system.

Establishing an exposure chart

Method

- Draw up a blank exposure chart (see Fig 6–1 and *Appendix B*, page 168).
- Fill in all the anatomical areas to be covered, listing the views for each.
- Divide these into groups using the same set of conditions. e.g. all extremities using detail screens, no grid, 100 cm FFD (SID).
- Produce a well exposed set of radiographs of an extremity, e.g. hand. (this can be done in the course of a routine examination.)
- Record the exposures used against HAND on the chart.
- Measure the thickness of the patient's hand in all projections used. e.g. PA, Oblique, lateral (see *Module 2. Accessory equipment*, page 41 and *Appendix A*, page 135).
- Measure thickness at the level of entry of the central ray, for each position of the hand.
- Measure all other areas/positions in the same group (these can be obtained from a colleague or friend of similar size rather than inconvenience the patient).
- Calculate the exposures for all other areas/positions in the group, based on the following chart (patient thickness related to exposure change), using the hand as your base level:

  Patient thickness related to exposure change
  — 1.5 cm increase in thickness requires a 25% increase in exposure (+1 step)
  — 5.0 cm increase in thickness requires a 100% increase in exposure (+3 steps)

Exposure chart

Room _____

Area	kV	mAs mA	Time	FFD (SID) cm	Grid	Screens	Remarks
Hand							
PA				100	—	Detail	
Oblique				100	—	Detail	
Lateral				100	—	Detail	
Wrist							
PA				100	—	Detail	
Oblique				100	—	Detail	
Lateral				100	—	Detail	
Forearm							
AP				100	—	Detail	
Lateral				100	—	Detail	
Elbow							
AP				100	—	Detail	
Oblique				100	—	Detail	
Lateral				100	—	Detail	
Foot							
DP				100	—	Detail	
Oblique				100	—	Detail	
Lateral				100	—	Detail	
Ankle							
AP				100	—	Detail	
Oblique				100	—	Detail	
Lateral				100	—	Detail	

Fig 6–1. An example of a partially completed exposure chart

— 5.0 cm decrease in thickness requires a 50% decrease in exposure (–3 steps)
— 1.5 cm decrease in thickness requires a 23% decrease in exposure (–1 step)

Note: The reference to "+ or – steps" is explained below *The step system*.

Example

- PA HAND (**2 cm thick**) Exposure **50 kV 6 mAs**.
- Calculate an exposure for a lateral WRIST (**7 cm thick**).
- Thickness difference between PA HAND and Lateral WRIST is **5 cm**.
- For an increase of **5 cm** the exposure is increased by 100% (see "Patient thickness related to exposure change", figures above).
- Therefore the lateral WRIST exposure will be **50 kV 12 mAs**.
- The exposures for all other areas of the body can be calculated in this way.

The step system

The step system is a simple, standardised form of exposure factor manipulation, designed to remove some of the guess work and make exposure setting more accurate.

It works on a series of step charts allowing the use of standard step changes in exposure.

It is also related to patient thickness (see *Appendix A*, pages 135 & 136) and medical condition (see Fig 6–5).

kV
40
41
44
46
48
50
52
55
57
60
63
66
70
73
77
81
85
90
96
102
109
117

Fig 6–2. kV step chart

Note: Step changes can be applied to any one of the charts or split between the charts.

- The step system provides step charts for kV, mA, mAs, time and FFD (SID), (see Fig 6–2, Fig 6–3, Fig 6–4 & Fig 6–5).
- To use the step system to make exposure changes, it is necessary to talk in terms of **steps**.
- **Each step** on any of the charts will alter the exposure by approximately **25%**.
- For a **noticeable change** in film density to be seen, the exposure must be altered by **at least 25%**.
- If a film is considered to be **too light or too dark** it will be necessary to change one of the exposure factors by **at least three steps** up or down.

mAs	mA	seconds
		.010
		.012
		.016
2	20	.020
2.5	25	.025
3.2	32	.032
4	40	.040
5	50	.050
6.4	64	.064
8	80	.080
10	100	.100
12.5	125	.125
16	160	.160
20	200	.200
25	250	.250
32	320	.320
40	400	.400
50	500	.500
64	640	.640
80	800	.800
100	1000	1.00
125		1.25
160		1.60
200		2.00
250		2.50
320		3.25
400		4.00
		5.00

Fig 6–3. mA, mAs and time step charts.

FFD (SID) cm
200
178
158
140
125
112
100
89
80
71

Fig 6–4. FFD (SID) step chart

- Any **step change** required to modify an exposure can be applied to any of the Step Charts, although other factors will influence this decision (contrast, penetration, patient dose, movement, limitations of the X-ray unit).
- Step changes need not be limited to one chart only. The necessary step changes can be split up between charts if necessary, providing that the overall number of required step changes is made.

Example

- Original Exposure = 60 kV 20 mAs
- New kV = 70 kV (an *increase* of 10 kV)
- An *increase* of 10 kV = *three steps* on the kV step chart.
- To retain the same density film, the *mAs* must be *reduced* by the same number of steps (*three steps*) on the *mAs chart*.
- New Exposure = 70 kV 10 mAs

Step charts

All step charts reproduced from "Course Notes in Basic Radiography", Radiation Protection Branch, South Australian Health Commission.

Exposure modification for changes in conditions

Pathology	**Step changes suggested**
Ascites	+2
Asthmatic	-1 or 2
Bowel Obstruction	-1 or 2
Emaciated	0
Emphysema	-1 or 2
"Flabby" Fat	-1
Muscular Physique	+1
Osteoporosis	-1 or 2
Paget's Disease	+1 or 2
Pleural Effusion	+1 or 2
Pneumonia	+1 or 2
Pulmonary Oedema	+1 or 2
Tuberculosis	+1
Plaster of paris	
Half	+1 or 2
Dry	+3
Wet	+4 or 5
Fibreglass	0 or +1
Grid	
Up to Ratio 8.1, 40 lines/cm at 80 kV	+5
Screens	
Detail to Fast	-3
Fast to Detail	+3 (ideally use mAs steps)

Note: These step changes are a guide only. You may need to modify this chart to suit your own conditions.

Fig 6–5. Suggested step changes for specific changes in conditions

Notes

TASK 26

Radiographic exposures

You have been asked to complete the exposure chart shown below

a) Calculate all other exposures on the chart, based on the information given against DP Foot and AP Hip.
b) Fill in all other relevant information.

Exposure chart

Area	kV	mAs	Thickness of Part cm	FFD (SID) cm	Grid	Screens
Foot						
DP	50	10	8	100	_____	Detail
Oblique						
Lateral						
Ankle						
AP						
Oblique						
Lateral						
Tibia & fibula						
AP						
Lateral						
Knee						
AP						
Lateral						
Femur (Lower 2/3)						
AP						
Lateral						
Hip						
AP	70	50	18	100	Bucky	Fast
Lateral						
Pelvis						
AP						

Tutor's comments:

Satisfactory/Unsatisfactory

Signed _____ Date _____

Tutor

TASK 27

Modify an exposure chart

Your department has just been supplied with new intensifying screens and your exposure charts are no longer accurate. Someone has worked out some exposures already and has asked you to modify the remainder.

a) Modify the following exposure chart.
b) Start by replacing the relevant exposures with the following exposures.
   HAND, PA 50 kV 8 mAs
   SHOULDER, AP 65 kV 16 mAs
   CHEST, PA 100 kV 5 mAs
c) Now modify all other exposures on the chart, using the step charts.
d) Enter the new exposures alongside the old ones.

Exposure chart

Area	kV	mAs	FFD cm (SID)	Grid	Screen
Hand					
PA	50	16	100	No	Detail
Oblique	50	20	100	No	Detail
Lateral	50	32	100	No	Detail
Wrist					
PA	50	16	100	No	Detail
Oblique	50	20	100	No	Detail
Lateral	50	25	100	No	Detail
Forearm					
AP	55	20	100	No	Detail
Lateral	55	25	100	No	Detail
Elbow					
AP	55	25	100	No	Detail
Oblique	55	25	100	No	Detail
Lateral	60	20	100	No	Detail
Humerus					
AP	60	32	100	Bucky	Fast
Lateral	60	32	100	Bucky	Fast
Shoulder					
AP	65	32	100	Bucky	Fast
SI	65	32	100	Bucky	Fast
Chest					
PA	90	5	180	Bucky	Fast
Oblique	90	5	180	Bucky	Fast
Lateral	100	5	180	Bucky	Fast

Tutor's comments:

Satisfactory/Unsatisfactory

Signed _____ Date _____

Tutor

TASK 28

Creating a new exposure chart

Your department has just been equipped with a new X-ray unit and you have been asked to produce an exposure chart for it.

a) Select an X-ray room.
b) Using the knowledge you have gained to date, establish a completely new exposure chart, for the X-ray unit in that room.
c) Draw up a chart and fill in all relevant information on your chart. e.g. patient positions, exposure factors, grid, screens, FFD (SID), patient size.
d) Submit the chart to your tutor for assessment.

Tutor's comments:

Satisfactory/Unsatisfactory

Signed _____ Date _____

Tutor