5.3 ASSESSMENT OF X-RAY TUBE OUTPUT PARAMETERS

5.3.1 Task

Assessment of X-ray Tube Output Consistency; Output variation with mA and with kV; Linearity. Assessment of the Focal spot size and the X-ray/Light beam alignment.

Approximate time for performing the task - 2 days.

5.3.2 Competencies Addressed

Understanding and measure the X-ray tube output parameters, focal spot size and LBD alignment. Seasoning of the X-ray tube.

5.3.3 Equipment and Materials

Electrometer with ionisation chamber ~ 6 cc.
kVp noninvasive meter (e.g. Keithley or RMI).
Focal spot test tool (e.g. RMI 112 B).
Collimator and beam alignment test tool (ex. RMI 53-62).
18x24 cm cassette (loaded with film).
Black film envelope.
X-ray film Developing facilities.
Tape measure.
Calculator.

5.3.4 Procedures and Measurements

5.3.4.1 Warming up of the X-ray tube

N.B. Before starting measurements the X-ray tube has to be warmed up (seasoning of the tube). For this, a minimum of three warming exposures have to be performed:

1. about 50 kV, about 50 mA and about 100 msec
2. about 50 kV, about 100 mA and about 200 msec
3. about 70 kV, about 100 mA and about 200 msec.

The minimum interval between the exposures has to be more than 1 minute.

5.3.4.2 Assessment of X-ray Tube Output Consistency

Position the ionisation chamber at 1 metre from the focal spot of the X-ray tube and at least 20 cm from any scattering object e.g. the patient couch. Collimate the X-ray beam to some 5 cm around the chamber.

Repeat the exposure a number of times on Broad focus and constant parameters (e.g. 80 kVp, 20 mAs) and record the measured air kerma for each exposure.

Repeat the measurements on Fine focus.

Focus	Set kVp	Set mA	Set msec	Set mAs	Measure kVp	Measure msec	Measure expos.	Air kerma
B	80			20				
B	80			20				
B	80			20				
B	80			20				
F	80			20				
F	80			20				
F	80			20				
F	80			20				

5.3.5 Assessment of X-ray Tube Output Variation with mA

Continue the measurements with the set up from 5.1.
Perform 4 exposures with constant kVp (e.g. 80 kVp) and exposure time, but with different mA (e.g. 50 mA, 100 mA, 200 mA, 400 mA).
Record the measured air kerma.

Focus	Set kVp	Set mA	Set msec	Set mAs	Measure kVp	Measure msec	Measure expos.	Air kerma
B	80	50						
B	80	100						
B	80	200						
B	80	400						

5.3.6 Assessment of X-ray Tube Output Variation with kV

(This can be done in conjunction with 5.4.4.2-5.4.4.4).
Continue the measurements with the set up from 5.1, but additionally place the kVp meter in the X-ray beam, in order to measure the real kVp's. The kVp meter should be at least 10 cm away from the ionisation chamber, to avoid back-scattered radiation hitting the ionisation chamber.
Perform at least 4 exposures with Broad Focus and with constant mA and msec (for ex. 200 mA and 100 msec), but with gradually increasing kVp (e.g. 60 kV, 80 kV, 100 kV, 120 kV).
Record the measured air kerma and kVp for each exposure.
Repeat the measurements with the Fine focus selected and possibly other kVp set (e.g. 50 kV, 70 kV, 90 kV, 110 kV).

Focus	Set kVp	Set mA	Set msec	Set mAs	Measure kVp	Measure msec	Measure expos.	Air kerma
B	60			20				
B	80			20				
B	100			20				
B	120			20				
F	50			20				
F	70			20				
F	90			20				
F	110			20				

5.3.7 Assessment of Focal Spot Size

Place an X-ray film in a black envelope on the patient table.
Place the focal spot test tool over the envelope with it's resolution pattern facing up and orientated parallel with the anode/cathode line of the X-ray tube.
As the tool is 6 inches high, the distance between the focal spot and the film in the envelope is adjusted to be 24 inches (if another tool is used, please refer to its manual).
Perform one exposure with the broad focus (approx. 50 kV and 40 mAs).
Develop and keep the film with the resolution pattern.
Repeat all above with the fine focus.

5.3.8 Assessment of the X-ray/Light Beam Alignment

Check visually the coincidence of the side light beam of the LBD with the middle of the bucky cassette tray.
Place a cassette with X-ray film (18x24 cm) on the patient table.
Set the distance between the film and the focal spot to 1 metre.
Place the test tool over the cassette (parallel to its edges).
Adjust the LBD collimator so that the light beam covers exactly the inner pattern of the test tool.
Perform an exposure with approx. 50 kV and 4 mAs.
Develop and keep the film with the image of the test tool.
Compare the irradiated black square on the film with the shadows of the inner pattern of the test tool and record its difference in mm.
Record the interposition of the shadows of the middle ring and point. (e.g. the point in the ring; the point out of the ring; the point on the ring's border, etc.).

5.3.9 Calculations

5.3.9.1 For Assessment of X-ray Tube Output Consistency

Calculate the Dose output consistency (%). This is the relation between the standard deviation and the average of the measured exposures (mGy) for each focus (100*STDEV/AVERAGE).
Compare the calculated value with the recommended limit of 5%.

5.3.9.2 For Assessment of X-ray Tube Output Variation with mA

Calculate the Specific Dose Output (mGy/mAs) for each exposure.
Plot each Specific Dose Output against the corresponding mA.
Comment on the (mGy/mAs)=F(mA) function.

5.3.9.3 For Assessment of X-ray Tube Output Variation with kV

Calculate the Specific Dose Output (mGy/mAs) for each exposure.
Calculate the kV^2 of the measured kVp for each exposure.
Plot each Specific Dose Output against the corresponding kV^2.
Comment on the linearity function (mGy/mAs)=F(kV2).

5.3.10 Observations , Interpretations, Conclusions

Comment on the necessity of X-ray tube seasoning.

Comment on the effect of Dose output inconsistency on film quality.

Observe and comment on changes in the (mGy/mAs)=F(kV^2) function and changes in the linearity related with higher energies.

Describe the scientific base of the method for focal spot size measurement.

Look in the Image Database for different Test objects for focal spot size measurement and explain their difference.

5.3.11 References

Manual for the Focal Spot Size Measurement Tool.
IPSM Report 32 - part I - X-ray tubes and generators.
Technical and Physical Parameters for Quality Assurance in Medical Diagnostic Radiology, BIR Report 18, 1989
E. Forster, Equipment for Diagnostic Radiology, MTP Press, 1993
M.Thompson, J. Hall, M.Hattaway, S.Dowd, Imaging Science and Protection, Saunders Co, 1994

Verification

Signature and date by the trainer:

Name of the Trainee:_____
Comments:_____
_____
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Date:_____Trainer's sign:_____