

TUBE LEAKAGE PROCEDURES AND MEASUREMENTS

1. GENERAL

In the recently published report No. 147 of the NCRP [1] it is stated that manufacturers are currently required by regulation to limit the leakage radiation to **0.876 mGy h⁻¹ (100 mR h⁻¹) at 1 m**. Compliance with this requirement is evaluated using the maximum X-ray tube potential and the maximum beam current at that potential for "continuous tube operation". These maximum tube potential and current ratings (kVp_{max} and I_{max}, respectively) are usually quoted as leakage technique factors. I_{max} depends on kVp_{max} and the values typically assumed for I_{max} are 3.3 mA, 4 mA and 5 mA for kVp_{max} of 150 kVp, 125 kVp and 100 kVp, respectively[1, 2].

Therefore, if measurement was performed at:

- 150 kVp use 3.3 mA for calculation;
- 125 kVp use 4 mA for calculation, or
- 100kVp use 5 mA for calculation

2. PROCEDURE

For Assessment of X-ray Tube Leakage Radiation

- Close the X-ray tube diaphragm and place the tube down on the X-ray table.
- Surround the X-ray tube with at least 6 big X-ray cassettes with films, forming a closed volume (cubicle) around the X-ray tube housing (number the films).
- Perform a heavy exposure (according to the X-ray unit possibilities kV_{max}) – for example 125 kV/200 mA for 1 sec.

Develop the films and identify the dark places on the films.

This is the preferred method, however if films are not available perform leakage measurements at areas around the tube with highest risk leakage by using procedure 1 or procedure 2.

2.1. PROCEDURE 1 – measurement performed on integral dose

Place a large volume ionisation chamber at the places, where the films are most dark (or highest risk area), 0.1 metre (d_m) from the tube housing, and **repeat the heavy exposure (125 kV/200 mA for 1 sec)** (see short cut below). Repeat the measurement at other places around the tube housing and record the values.

2.1.1. Calculation for Procedure 1 (example above @ 125 kV and 200 mAs)

Highest reading (mR or mGy) x 4 mA ÷ 200 mAs x 3600 (to convert exposure to h⁻¹) x (0.1/1)² (inverse square law) = mR h⁻¹ or mGy h⁻¹

PS 200 mAs can be obtained with 400 mA for 0.5 seconds or 200 mA for 1 second or 100 mA for 2 seconds or 50 mA for 4 seconds. For all four options divide by 200 mAs and multiply by 3600 to convert to h⁻¹. To prevent tube damage, use the longest time with the lowest mA.

2.2. PROCEDURE 2 - measurement performed on dose rate

Set at highest kV_{max} (e.g 125 kV), lowest mA (e.g. 50 mA) longest exposure time (e.g. 5 seconds). To ensure accurate measurements in dose rate, you must use a long exposure. Set the survey monitor to dose rate (mR h⁻¹ or mGy h⁻¹). Make exposure and perform measurement at 1 metre from the tube housing where the films are most dark (or highest risk area). Repeat to cover the whole tube and record highest reading.

2.2.1. Calculation for Procedure 2 (example above @ 125 kV and 50 mA)

Highest reading (mR h⁻¹ or mGy h⁻¹) x 4 mA ÷ 50 mA = mR h⁻¹ or mGy h⁻¹

References

1. National Council on Radiation Protection and Measurements. Structural shielding design for medical X-ray imaging facilities. NCRP Report 147. Bethesda, MD: NCRP, 2004.
2. Simpkin DJ, Dixon RL. Secondary shielding barriers for diagnostic X-ray facilities: scatter and leakage revisited. Health Phys 1998;74:350–65.