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DETERMINATION OF EQUIVALENT COPPER THICKNESS OF PATIENT EQUIVALENT PHANTOMS IN TERMS OF ATTENUATION, USED IN RADIOLOGY.

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In the radiation protection research programme of the European Union, as part of the DIMOND concerted action, constancy check protocols for fluoroscopic systems have been developed [1]. For practical reasons copper filters are preferred to patients and tissue equivalent, water or PMMA, phantoms. The objectives are to derive patient entrance surface dose rates and the dose rate at the image intensifier input. The protocol states that copper sheets of either 1 mm or 1.5 mm thick may be used. The present study investigates the equivalent thickness of copper filters compared to PMMA phantoms in terms of attenuation for both geometries and different tube voltage and filter combinations.

The geometry to determine the patient entrance surface dose [1] is with the copper filter close to the image intensifier. The ionisation chamber is placed on the side of the copper sheet nearest to the X-ray tube. The inverse square law is used to correct for differences in position. Measurements are performed with different settings and with and without the use of an anti-scatter grid.

The geometry to determine the air kerma rate at the image intensifier [1] is with the copper filter attached to the X-ray tube diaphragm. The ionisation chamber is placed on the surface of the image intensifier housing. Again measurements are performed with different settings and with and without anti-scatter grid. If necessary, the inverse square law correction is applied.

Two different radiation beam sizes are used, i.e., a small beam with a diameter of 0.10 m at a distance of 1.00 m from the focus and a large beam with a diameter of 0.23 m at a distance of 1.00 m from the focus. The applied tube voltages and PMMA phantom thickness combinations are 60 kV, 13 cm; 80 kV, 14 cm; 100 kV, 16 cm; 120 kV, 17 cm; 150 kV, 18 cm; 150 kV, 20 cm and 150 kV, 30 cm.

The spectra for the different tube voltages are generated with the IPEM Report 78 software [2] at an anode angle of 16 degree, 0% ripple and 2.5 mm added aluminium filtration. The Monte Carlo N-Particle transport code (MCNP) [3] is used to calculate the attenuation in the different geometries with the PMMA or copper or no filters applied. In all these cases the detector is placed at 1.0005 m distance from the focus on the central beam axis, with all filters between the detector and the focus. No anti-scatter grid is used in these calculations. With different thickness of the PMMA phantom and appropriate tube voltage the attenuation is calculated. The copper filter thickness is adjusted to get the same attenuation as obtained with the relevant PMMA phantoms. This match is made for the PMMA-phantom in front of the image intensifier and the copper filter in front of the image intensifier or attached to the X-ray tube diaphragm. In addition a match is made with both the PMMA and copper filter attached to the X-ray tube diaphragm. The image intensifier is simulated by a CsI plate 0.5 mm thickness, placed at 1.001 m from the focus. The front filters are placed 0.15 m from the focus and the back filters are ending 1.00 m from the focus.

The results will be presented as the copper equivalent filter thickness for the PMMA phantom thicknesses mentioned above for different tube voltages and both beam geometries.

The situation with both the PMMA phantom and copper filter in the back position is used to estimate the patient entrance surface dose rates. The equivalent copper filter calculation is based on the detector behind the attenuators to simulate the performance of an Automatic Exposure Controller (AEC). In addition detectors are placed 0.5 mm in front of the PMMA phantom and the copper filter and corrected by the inverse square law to a focus detector distance of 0.50 m [1]. Comparison between both situations is made to estimate the uncertainty in the ionisation chamber measurement.

The equivalent copper filter is based on equal attenuation therefore the beam quality will, in general, be different. In order to characterise these differences for both the PMMA and copper attenuated beam the average photon energy and an estimate of the HVL in aluminium will be presented. These quantities are derived from the photon energy spectrum that is calculated on the detector.

Preliminary results indicate that instead of the in the protocol mentioned 1 mm or 1.5 mm thick copper sheets, thicknesses ranging from 0.4 to 7.5 mm thick copper sheets are needed to achieve the same attenuation with the PMMA phantom in back position, without an anti-scatter grid.

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