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363

FLAT IONIZATION CHAMBERS AS MONITORS IN X RAY BEAMS

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10354

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ABSTRACT

The performance of two flat ionization chambers, designed for dose measurements behind phantoms, was studied in the established diagnostic radiation qualities, radiology level, at the Calibration Laboratory of IPEN, with filtering corresponding to a position in front of a patient. The chambers were positioned, sequentially, in front of the collimator as monitor chambers. The air kerma rates measured with the reference ionization chamber, using each of the flat ionization chambers positioned in the field, showed a decrease of less than 15%, showing their usefulness as monitor chambers.

INTRODUCTION

In recent years several studies have been realized to specify performance standards for equipment used in diagnostic radiology, with the objective of obtaining adequate diagnostic information at acceptable levels of patient dose[1-5]. Considering that the calibration of the instruments used in diagnostic radiology measurements is essential, and that about 25% of the instruments used for routine measurements may require some adjustments[6], special methodologies for the calibration of this kind of instruments were established at the Calibration Laboratory of IPEN[7,8,9]. The methods may be applied in the calibration procedures of survey meters used for radiation protection measurements, instruments used in direct beams, and quality control instruments.

The objective of this work was to study the performance of two flat ionization chambers, designed for dose measurements behind phantoms, as monitor chambers in X-ray beams, with filtering corresponding to a position in front of a patient.

MATERIALS AND METHODS

The radiation qualities recommended by the international standard IEC 61267[10] were established using a Medicor Mövek Röntgengyara X-ray generator, model Neo-Diagnomax (125 kV), from 50 to 90 kV, in the fluoroscopic mode, and for 100 kV in the radioscopic mode.

The dosimetric reference system was a 1.0 cm^3 parallel plate ionization chamber, Physikalisch-Technische Werkstätten, model 77334, traceable to the German Primary Dosimetry Laboratory, Physikalisch-Technische Bundesanstalt. This chamber was connected to an electrometer PTW type UNIDOS 10001. The established qualities are showed in Table1.

The flat ionization chambers (112 cm^3) PTW, model 77335, designed for dose measurements behind phantoms, were originally calibrated from 50 to 150 kV with patient-equivalent filtering. In this work they were tested in established qualities with filtering corresponding to a position in front of a patient (total filtration of 2.5 mmAl); an additional measurement was taken at 100 kV and 200mAs, in the radioscopic mode, using the same filtration. A ^{14}C check source with a nominal activity of 3.7 MBq (1993) was used for the stability and repeatability tests. The chambers were connected to a PTW electrometer, model UNIDOS 10001. They were positioned, sequentially, in front of the collimator as monitor chambers. Each one of the flat chambers was irradiated at the distance of 11 cm simultaneously with the reference ionization chamber (1 cm^3), positioned at the calibration distance of 100 cm.

RESULTS

The stability and repeatability tests, including the leakage current test, showed a good performance for both flat ionization chambers using the ^{14}C check source: a maximum variation of 0.5 % for the long term stability test, and a standard deviation of 0.3 % in the repeatability measurements were obtained. The leakage current was always less than 0.5% of the reference air kerma rates.

Initially, the air kerma rates were measured with the reference ionization chamber. Using each of the flat ionization chambers positioned in the field, the air kerma rates were measured again by the reference ionization chamber. The values obtained are listed in Table 2. A maximum decrease of only 7.1% in the case of chamber **B** and 14.0 % in the case of chamber **A** can be observed, showing the possibility of their use as monitor chambers. The uncertainties were always less than 5.5%.

The response of the two flat ionization chambers, in comparison with the reference ionization chamber response, at the calibration distance, resulted in the calibration coefficients presented in Table 3. The difference between these values and the values in the original calibration certificates (for patient filtering equivalent- 32.5 mmAl) provided by the Deutscher Kalibrierdienst, DKD, Germany, is less than 10% for each ionization chamber, showing a good behaviour of the flat chambers for radiation intensity measurements too. The uncertainties were always less than 5.5%.

CONCLUSIONS

The performance of the two ionization chambers shows the possibility of their use as monitor chambers in the Neo-Diagnomax X radiation system of the Calibration Laboratory of IPEN. Moreover, the calibration coefficients obtained allow the use of the flat ionization chambers as working standards for the calibration of field instruments.

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Table 1: Diagnostic radiology qualities established at the Medicor X-ray system of the Calibration Laboratory of IPEN.

Operation Mode	Radiation Quality	Nominal Tube Voltage (kV)	Total Filtration (mmAl)	Half-Value Layer (mmAl)	Effective Energy (keV)
Fluoroscopic	RQR 3	50	2.5	1.82	32.0
	RQR 5	70	2.5	2.45	39.2
	RQR 7	90	2.5	3.10	46.0
Radioscopic (200 mAs)	RQR 8	100	2.5	3.59	48.0

Table 2: Air kerma rates measured with the reference ionization chamber with and without the flat ionization chambers **A** and **B** positioned in the field.

Tube Voltage (kV)	Half Value Layer (mmAl)	Air Kerma Rate (mGy/min)		
		Without Monitor Chamber	With Chamber A	With Chamber B
50	1.82	6.37	5.64	6.15
70	2.45	11.5	10.9	11.0
90	3.10	15.0	13.2	14.0
100	3.59	6.15	5.83	5.78

Table 3: Calibration coefficients obtained for the tested flat ionization chambers at the Calibration Laboratory of IPEN.

Tube Voltage (kV)	Half-Value Layer (mmAl)	Calibration Coefficient ($\times 10^5$ Gy/C)	
		A	B
50	1.82	7.66	7.30
70	2.45	7.27	7.18
90	3.10	7.88	7.36
100	3.59	2.83	2.75