DEVELOPMENT OF A CALIBRATION METHODOLOGY OF THE PATIENT DOSE CALIBRATOR

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Abstract

The kerma-area product (PKA) is a useful quantity to establish the reference levels in diagnosis of conventional X ray examinations. A KAP meter can be calibrated in laboratory or in situ, where it is used. The patient dose calibrator (PDC) is a new equipment from Radcal that measures P_{KA}. It was manufactured following the IEC 60580 recommendations. The aim of this study was to calibrate the PDC in order to use it as a standard device for calibration of KAP meters. The materials used were: a radiation system, the PDC, a monitor ionization chamber and an RC6 ionization chamber. The monitor ionization chamber was calibrated against the RC6 secondary standard ionization chamber. After that, the PDC was calibrated using the monitor ionization chamber as reference. The calibration of the PDC in radiation standard beams allows the determination of a special procedure to calibrate the KAP meter. Its behaviour demonstrates low energy dependence and it can be used as a reference instrument to calibrate clinical KAP meters.

1. INTRODUCTION

The kerma-area product (PKA) is a useful quantity to establish the reference levels in diagnosis of conventional X ray examinations and it is a good indicator when the dose limits for deterministic effects are achieved in interventionist procedures. According to the International Atomic Energy Agency (IAEA), the air kerma–area product, PKA, is the integral of the air kerma over the area of the X ray beam in a plane perpendicular to the beam axis.

The P_{KA} can be obtained by the use of the kerma-area product meter (KAP) which monitors the patient's exposure during the exam. It is important to use one reference KAP meter to obtain a reliable quantity of doses on the patient. A KAP meter can be calibrated in laboratory or in situ, where it is used. However, in general, the KAP chamber is fixed to the X ray equipment which means that it can't be calibrated in a laboratory, just in situ [1, 2, 3].

Thus, the calibration is usually done in situ using the P_{KA} quantity obtained from the measurements of the air kerma with a reference ionization chamber and the irradiated area exposed on the film positioned in the same distance as the chamber [2, 3].

The Patient Dose Calibrator (PDC) is a new equipment from Radcal that measures PKA. It was manufactured following the IEC 60580 recommendations. [3, 4] Its rated range of use for the tube voltage is between 40 kV and 150 kV, but studies have shown that measurements can be done under 40kV [5]. This is an instrument for field calibration of patient dose measurement and it has the advantage of being able to use different field sizes, radiation qualities and to have smaller energy dependence. There are few studies about the use of the PDC as it is a new device [4-11].

The Laboratório de Calibração de Instrumentos (LCI) at Instituto de Pesquisas Energéticas e Nucleares (IPEN) is performing studies with the PDC, and it has already done its performance evaluation in mammography radiation qualities and characterized it according to the IEC 61674. [10,11]

The aim of this study was to calibrate the PDC in order to use it as a standard device for calibration of KAP meters.

2. MATERIALS AND METHODS

The instrument used to measure the PKA was the Patient Dose Calibrator from Radcal. The PDC is a reference class instrument for field calibration of patient dose measurement and control systems thus ensuring the validity of inter-institution patient dose comparisons. Figure 1 shows the PDC [9].

FIG. 1. Patientd dose calibrator.

The X Radiation system used was a Pantak/Seifert located at the LCI, with a voltage up to 160 kV, a tungsten target, a constant potential, an inherent filtration of 0.138 mmAl and a 0.8 mm beryllium window. Figure 2 shows the X radiation system.

Two ionization chambers were used. The RC6 is an unsealed cylindrical 6 cm^3, general-purpose ion chamber from Radcal, designed for general purpose X ray measurements. It has excellent energy response throughout the diagnostic energy, and it was calibrated by the Primary Standard Dosimetry Laboratory PTB, Germany. The other one was the monitor ionization chamber from PTW, model 34014 with large size plane parallel transmission chambers for use as dose monitors combined with calibration facilities like vented sensitive volumes of 94 cm^3 and 86 cm^3. It includes twin-measuring volumes, shadow-free transmission chambers for dose monitoring and with calibration facilities.

The PDC was placed in front of the X ray equipment with the central beam positioned on the PDC's center. All the measurements were done using a current of 10 mA, distance of 1 meter, irradiations of 30 seconds and five irradiations for each energy. The temperature and pressure were automatically adjusted by the PDC. Figure 2 shows the PDC properly positioned.

FIG. 2. Position of the PDC on the X ray beam.

The measurements were performed in four radiation qualities in radiation beams emerging from the X Ray Source Assembly (RQR) at the LCI. The four RQR used (3, 5, 8 and 10) corresponding to 50 kV, 70kV, 100kV and 150kV respectively, were established at the LCI in a study performed at IPEN in Brazil in 2010, which follows the IEC 61267 regulation [11] not in reference list.

The monitor ionization chamber was calibrated against the RC6 secondary standard ionization chamber. After that, the PDC was calibrated using the monitor ionization chamber as reference.

3. RESULTS

Using the secondary standard ionization chamber RC6, the characteristics of the radiation qualities were determined and can be seen in Table 1.

TABLE I. MAIN CHARACTERISTICS OF THE RADIATION QUALITIES ESTABLISHED AT LCI.

Radiation qualities	Tube voltage, (kV)	Half value layer, (mmAL)	Air kerma rate, (mGy/min)
RQR 3	50	1.78	21.1
RQR 5	70	2.58	36.86
RQR 8	100	3.97	67.82
RQR 10	150	6.57	121.18

The monitor ionization chamber was calibrated positioned just after the filter wheel. It was placed where it could be kept during the PDC calibration. The PDC-focus distance was 100 cm. Table 2 shows the calibration coefficient found for the monitor chamber and the PDC. All values were corrected to the ambient conditions as they are vented. The uncertainties were always less than 4% to 95% of confidence level and coverage factor of 2.

TABLE II. CALIBRATION COEFFICIENT OF THE MONITOR IONIZATION CHAMBER AND OF THE PDC.

Radiation qualities	Voltage (kV)	Calibration coefficient (Nk) (mGy/s.u.)	
		Monitor ionizantion chamber	PDC
RQR 3	50	$1{,}095.10^2$	2.01
RQR 5	70	$1{,}048.10^2$	1.99
RQR 8	100	$1{,}058.10^2$	1.97
RQR 10	150	$1{,}536.10^2$	1.91

4. CONCLUSION

The calibration of the PDC in radiation standard beams allows the determination of a special procedure to calibrate the KAP meter. Its behavior demonstrates a low energy dependence and it can be used as reference instrument to calibrate clinical KAP meters.

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(Note: Only one item per number. Your reference 2 has been split into Ref 2 and Ref 3, and the following items re-numbered.)

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