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EVALUATION OF AN IONIZATION CHAMBER RESPONSE WITH DIFFERENT PHANTOMS IN DIAGNOSTIC RADIOLOGY FIELDS

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ABSTRACT

This present work shows the behaviour of an ionization chamber with volume of 180 cm^3 used in diagnostic radiology measurements in X radiation standard fields using two different acrylic phantoms, one is a slab phantom and the other is a head-neck phantom. This special model of ionization chamber (Radcal, 10x5-180) can be used to perform measurements in field and scattered radiations. The radiation qualities were established in a X-radiation system in order to calibrate ionization chambers and other dosimeters to diagnostic radiology applications. The results showed a variation in the calibrations coefficient of 10% in the range studied (from 50 to 150 kV).

1. INTRODUCTION

The Instruments Calibration Laboratory (LCI) of IPEN performs calibrations of all radiation measurement instruments used in diagnostic radiology (such as ionization chambers and others) using the specific radiation qualities recommended by the standard IEC 61267 [1]. The ionization chambers used in diagnostic radiology measurements may have different shapes and volumes depending on their specific applications such as mammography, computed tomography (CT), fluoroscopy, general radiology, scattering and leakage measurements (including radiation protection level). Consequently their calibration has to be specific too and the behaviour of these instruments needs to be known in order to be adequately used. While the calibration measurements are made free in air, the user measurements are usually done using simulators (phantoms) as recommended by the Brazilian Health Ministry publication 453 [2]. One of the most common types of ionization chambers used in diagnostic radiology and calibrated at LCI is the parallel plate type with 180 cm^3 of volume which can perform measurements in field and scattered radiations. The objective of this study is to analyse the behaviour of this particular ionization chamber in standard X radiation fields using acrylic neck ant slab phantoms.

2. MATERIALS AND METHODS

The measurements with the ionization chamber Radcal, model 10x5-180 were done using two acrylic cylinder phantoms, one is a slab phantom with diameter of 30 cm and width of 15 cm and the other is a head-neck phantom with diameter and width of 16 cm. The ionization chamber was placed just in front of the phantoms and the irradiations were performed in two distances, 100 cm and 250 cm, allowing the complete irradiation of the phantoms. Fig. 1 shows the set-ups utilized to the irradiation.

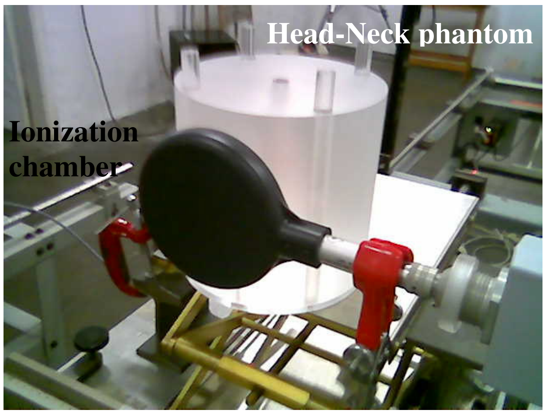

Figure 1. Set-up used to irradiate the ionization chamber in front of the phantoms.

The standard radiation qualities were established [3] using a secondary standard ionization chamber, PTW, model 77334, volume of 1 cm^3 calibrated at the primary standard laboratory PTB, Germany. These qualities, recommended by IEC 61267, are shown in Table 1. The X radiation system used was a Seifert, model ISOVOLT 160HS, from 50 to 150 kV.

Table 1. Diagnostic radiology radiation qualities established at Seifert X radiation system, from 50 to 150 kV. Irradiation reference distance = 100 cm

Radiation Quality	Tube Voltage (kV)	Half Value Layer (mmAl)	Homogeneity Coefficient	Effective Energy (keV)	Air Kerma Rate (mGy/min)
RQR 3	50	1.79	0.75	27.15	24.06
RQR 5	70	2.35	0.69	30.15	47.17
RQR 7	90	2.95	0.64	33.05	74.51
RQR 9	120	3.84	0.61	37.05	121.80
RQR 10	150	4.73	0.61	40.75	175.19

The measurements made when the phantoms were in the field were done at distance focus-detector (DFD) of 250 cm (field diameter of 42 cm) to guarantee the complete irradiation of the phantoms. To determine the calibration coefficients in that condition the reference ionization chamber was too irradiated at that distance and the entrance surface air kerma was determined (considering the backscattered radiation).

3. RESULTS

The calibration coefficients of the studied ionization chamber were determined in three different conditions. First of all they were determined free in air at 100 cm, and then measurements were made in front of the phantoms (head-neck and slab). Its behaviour can be observed in Figure 2. All measurements were corrected for the environment conditions (temperature and pressure) because the ionization chamber is not sealed.

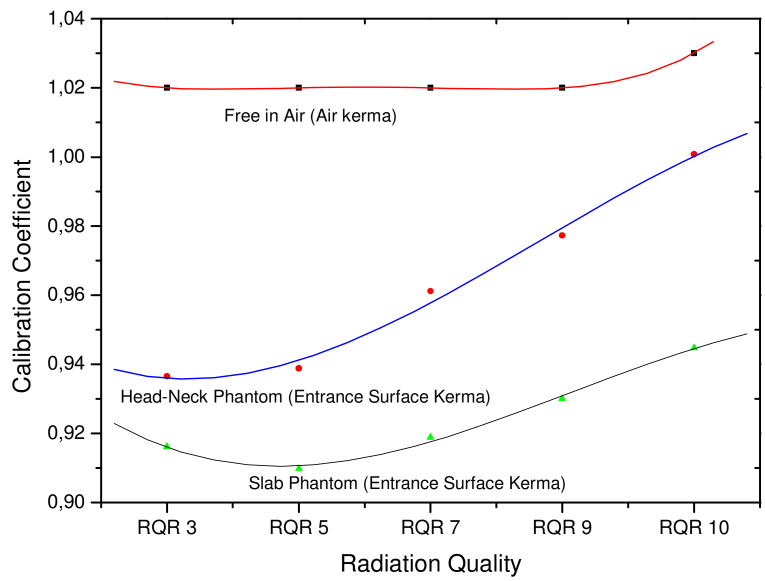

Figure 2. Calibration coefficients for the 180 cm^3 ionization chamber in terms of air kerma (DFD= 100 cm) and in terms of entrance surface air kerma for head-neck and slab phantom (DFD= 250 cm).

The calibration coefficients obtained when the irradiations were made free in air showed a variation always less than 3%. Comparing the reference air kerma rates with the measurements made in front of the phantoms, the variation of the responses can reach 11% (RQR 5). The worse calibration coefficients were obtained when the slab phantom was used (from 0.91 to 0.95), with a maximum variation of 9%, representing an energetic dependence of 3.7% in the studied X radiation range. To the measurements with the head-neck phantom, the calibration coefficients were a little better, varying from 0.93 to 1.0 (maximum variation of 6%), but the energetic dependence was higher, representing 6.4 %.

4. CONCLUSIONS

The results showed the importance of better knowledge of the behaviour of the ionizations chambers used in diagnostic radiology measurements considering the need of perform measurements using simulators as recommended by national norms and that the calibrations are performed by the reference laboratories in terms of air kerma. This kind of study may be extended to the others types of ionization chamber used in diagnostic radiology measurements.

ACKNOWLEDGMENTS

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