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PRELIMINARY CHARACTERIZATION OF AN EXTRAPOLATION CHAMBER FOR BETA RADIATION DETECTION

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ABSTRACT

A commercial PTW extrapolation chamber (model 23391) was tested into a quality control program; its performance was evaluated using a check device of ^{90}Sr + ^{90}Y. Some characteristics as saturation curve, efficiency, polarity effect, repeatability and medium term stability tests were realized. The chamber depth was kept constant at 1.00 mm. A check device support was developed to allow the geometry constancy of the experimental set-up. Based on the saturation curve, the operational potential was established at ± 200 V in this work. The polarity effect obtained was 35%. The extrapolation chamber showed an efficiency of 99% for negative polarity and 97% for positive polarity. The repeatability tests presented a maximum variation of 1.0% and the medium term stability tests presented a maximum variation of 1.9%. The results are in accordance with international recommendations. The leakage current was negligible in all measurements.

1. INTRODUCTION

The extrapolation chamber is a device that allows direct determination of air kerma rates presenting good response for low energy X-rays and beta radiation. The extrapolation chambers are special parallel-plate designed chambers that allow variation of the air cavity mass through a controlled change in the electrode separation; they may be utilized as primary standard chambers for weakly penetrating radiations; therefore, the integrated electric charge in a volume of mass can be measured accurately [1].

Since Failla [2] designed the first extrapolation chamber, these chambers have been mainly used for the determination of relative surface doses in orthovoltage [2] and megavoltage [3] photon beams, and also in the dosimetry of beta radiation [4-6]. As beam dosimetry in radiotherapy and diagnostic radiology require accurate measurements, the use of extrapolation chambers, as primary standards for low energy X-rays and beta radiation is very useful.

At the Calibration Laboratory of IPEN, extrapolation chambers were built for use as reference systems to calibrate dermatological and ophthalmic applicators [7, 8].

In this work, a commercial PTW extrapolation chamber was tested in a quality control program for a future set-up of a standard measuring device to verify the unit for the quantity air kerma rate for soft X-rays and absorbed dose for beta radiation.

The performance of the commercial extrapolation chamber was evaluated using a check device of ^{90}Sr + ^{90}Y, and characteristics as saturation curve, efficiency, polarity effect, repeatability and reproducibility were studied. In the case of beta radiation, the results obtained in this work will be compared with those of a former characterization of this chamber by Caldas [9].

2. MATERIALS AND METHODS

The PTW extrapolation chamber (model 23391) presents electrodes and guard rings made of tissue equivalent material. The distance between the chamber electrodes can be changed from 0.5 mm to 25.0 mm using a micrometer. The 0.025 mm polyimide entrance window and the 40.0 mm diameter collecting electrode were used. In this study, the chamber depth was kept constant at 1.00 mm. A check device support was developed to allow the geometry constancy of the experimental set-up. For ionization current measurements, a digital PTW UNIDOS E electrometer was utilized.

To determine the saturation curve, the potential was varied from -350 V to 350 V, in increments of 50 V. The operational potential was obtained.

The polarity effect was determined using Equation 1:

$$p = \frac{Q_+ - Q_-}{Q_+ + Q_-} \qquad (1)$$

Q_+ e Q_- are the electric charges measured at the positive and negative polarities respectively.

The chamber efficiency was determined by the two potential method using Equation 2:

$$k_s = \frac{(V_1/V_2)^2 - 1}{(V_1/V_2)^2 - (M_1/M_2)} \qquad (2)$$

M_1 and M_2 are the measurements obtained at potentials V_1 and V_2 respectively; in this work $V_1 = \pm 200$ V and $V_2 = \pm 350$ V were utilized.

For the measurements of repeatability and medium term stability (also called reproducibility) tests, the collected charges were measured at both polarities and the mean values were adopted. The leakage current was determined in a time interval of 1200s.

3. RESULTS

The saturation curve was determined, and it is shown in Figure 1; the operational potential was established at ± 200 V in this study.

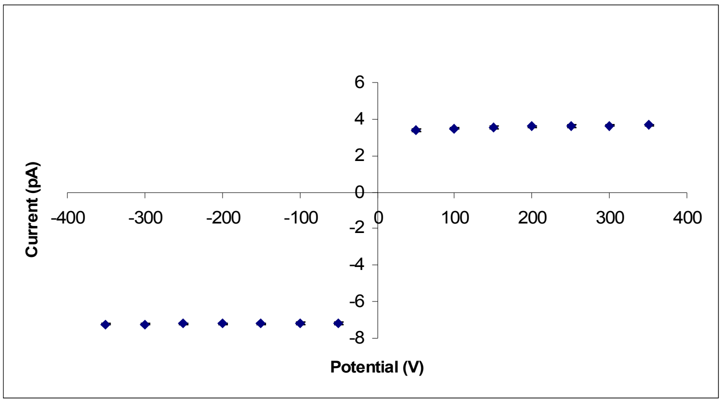

Figure 1: Saturation curve of the extrapolation chamber

The polarity effect was determined using Equation 1; the value obtained was 35% for the operational potential of 200 V. This value is high, but it is acceptable for beta radiation, since in this case there is a current generated from collisions of beta particles from the source with the chamber collecting electrode. This current (I_β) increases with the energy of beta particles. I_β become negligible when the mean value of the current measurements in positive and negative polarity is taken [10].

The extrapolation chamber efficiency was obtained using Equation 2 for positive and negative polarities, and the values obtained were respectively: 97% (k_s =1.03) and 99% (k_s=1.01).

For the repeatability tests several groups of ten consecutive measurements, in the same conditions, were obtained. These tests presented a maximum variation of 1.0% in the measurements. The medium term stability was obtained performing repeatability tests at consecutive days and normalizing the values for the mean value obtained at the ten first repeatability tests. Results are presented in Figure 2, and a maximum variation of 1.9% was obtained. The leakage current presented values lower than 0.01 pA. Therefore, the leakage current was always negligible.

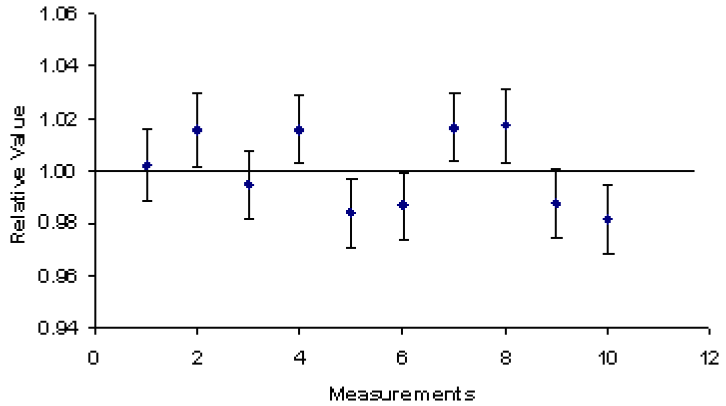

Figure 2: Medium term stability of the extrapolation chamber

4. CONCLUSIONS

The characterization of the PTW extrapolation chamber was obtained successfully: ±200V is the operational potential established, and 35% is the polarity effect. The extrapolation chamber showed an efficiency of 99% for the negative polarity and 97% for the positive polarity. The repeatability test presented a maximum variation of 1.0% in the measurements, and the medium term stability test presented a maximum variation of 1.9% in the measurements. The leakage current was negligible.

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