

COMPARISON BETWEEN A COMMERCIAL AND A HOMEMADE IONIZATION CHAMBERS FOR DOSIMETRY OF ^{60}Co BEAMS

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ABSTRACT

The Calibration Laboratory at IPEN/CNEN (LCI) has developed several ionization detectors, for dosimetry in diagnostic radiology, radiation protection and radiotherapy. Recently, a cylindrical ionization chamber, with a sensitive volume of 1.06cm^3 , was developed, and several tests were performed to characterize this ionization chamber for radiotherapy level. The results showed that its performance was within the recommended international limits. In order to complement the studies regarding the response of this ionization chamber, in this work, the chamber response was compared with that of a commercial ionization chamber Farmer PTW, model TN30011-1. The ionization chamber produced at LCI is made of PVC and PMMA. A special build-up cap for ^{60}Co beams was made of acrylic, with 4.00 mm thickness. All tests of both ionization chambers were performed under the same conditions, allowing good geometrical reproducibility. The performed tests were: saturation, ion collection efficiency, polarity effect and chamber tilt. The results obtained in this comparison program were all within the international recommendations, and demonstrate a good agreement of the performance of the commercial and the homemade ionization chambers. From this comparison results and from previous data, it is possible to conclude that the ionization chamber produced at IPEN presents usefulness for dosimetric applications at radiotherapy level in ^{60}Co beams.

1. INTRODUCTION

The ionization chamber is the most widely type of dosimeter utilized for precise measurements, such as those required in radiotherapy. The ionization chambers are commercially available in a variety of designs for different applications.

At the Calibration Laboratory of IPEN/CNEN-SP (LCI), several ionization chambers were developed, for dosimetry in radiotherapy [1], diagnostic radiology [2] and calibration procedures [3], as well for use as working standards [1]. These ionization chambers were developed using materials available at the Brazilian market, with the aim to produce radiation detectors that follow international recommendations, but with low cost.

In order to assure the quality control of the dosimeters produced at LCI, several tests and comparisons have to be undertaken. All dosimeters must attend international recommendations [4, 5], and the results must be compared with those of standards present at LCI.

Recently, a cylindrical ionization chamber, with a sensitive volume of 1.06cm^3 , was developed and several tests were performed to characterize this ionization chamber for the radiotherapy level [1]. All tests were successful, and this ionization chamber is suitable for

dosimetric procedures. This ionization chamber was also tested for different applications, as radiotherapy [1] and radiation field mapping [6], but until now, it has not been compared against a commercial ionization chamber, at the radiotherapy level.

In this work, the objective was to compare the performance of this new ionization chamber with that of a commercial ionization chamber, PTW model TN30011-1 used for routine calibrations at LCI. Following international recommendations [4], the characterization tests performed for both ionization chambers were: saturation, ion collection efficiency, polarity effect and chamber tilt.

2. MATERIALS AND METHODS

The ionization chamber produced at LCI is made of PMMA, with a sensitive volume of 1.06 cm^3 . The collecting electrode is made of aluminum, with a diameter of 1.20 mm, and the sensitive volume walls are made of PVC coated with graphite. The chamber internal diameter is 6.70 mm, and its wall thickness and sensitive length are 0.26 mm and 30.00 mm, respectively. In order to ensure the electronic equilibrium, a special build-up cap for ^{60}Co beams was made of acrylic, with 4.00 mm thickness. This ionization chamber and the build-up cap are shown in Figure 1.

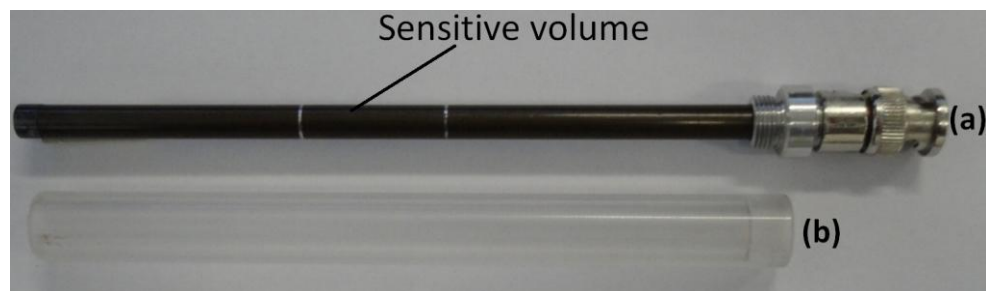


Figure 1. (a) Ionization chamber developed at LCI, and (b) build-up cap.

The commercial ionization chamber used for this comparison program was a PTW Farmer, model TN30011-1. This ionization chamber is shown in Figure 2, and has a sensitive volume of 0.6 cm^3 , with a collecting electrode and walls of graphite.



Figure 2. Commercial ionization chamber (a) PTW Farmer, model TN30011-1, and (b) its build-up cap.

In order to ensure reliable results, both ionization chambers were connected to the same electrometer, PTW Unidos E, and using the same cable. All measurements were taken under the same conditions.

Although the results for both ionization chambers were corrected for environmental conditions [7], care was taken to maintain the room at the same temperature and humidity during the tests. The variations in room temperature and humidity were lower than 1% during all tests. The variation in the atmospheric pressure was lower than 0.06%.

According to international recommendations [4], the performed tests were: saturation, ion collection efficiency, polarity effect and chamber tilt. All tests were made utilizing a Gammatron irradiator with a ^{60}Co source (air kerma rate of (0.76 ± 0.01) mGy/s). The ionization chambers were placed at 1.0 m from the source, and for the chamber tilt, both ionization chambers were connected to a positioning system (Figure 3), in order to allow geometrical reproducibility. This system uses a PMMA support, connected to a goniometer, OPTRON, model GN1 200.

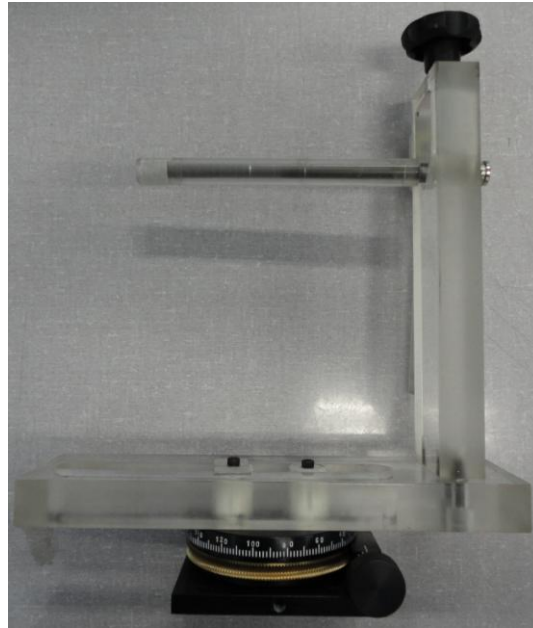


Figure 3. Positioning system used for the chamber tilt tests, with a goniometer.

3. RESULTS AND DISCUSSION

As stated in the international recommendations [4], the homemade and commercial ionization chambers were submitted to the following tests: saturation, ion collection efficiency, polarity effect and chamber tilt.

3.1. Saturation Curve

During this test, the applied voltage was varied from -400 V to +400 V in 50 V steps. The electric charge was collected each time during 15 s. The maximum variation of the ionization current during the saturation test was 0.8% for the commercial ionization chamber and 0.9% for the homemade ionization chamber, indicating that the saturation was achieved in the entire tested interval. The results are shown in Figure 4.

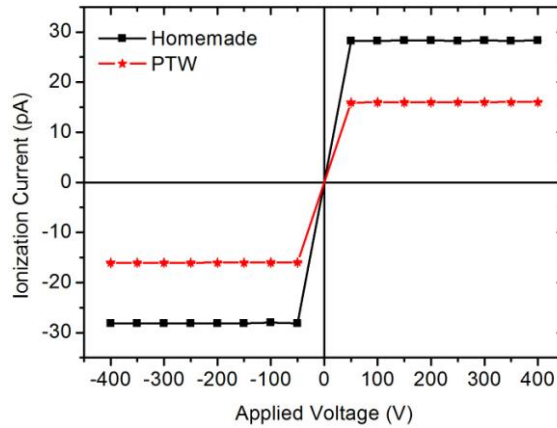


Figure 4. Saturation curves of the homemade and commercial PTW ionization chambers.

3.2. Ion Collection Efficiency

The ion collection efficiency may be obtained by the saturation curve, applying the two polarity voltages method [8]:

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

where M_x is the collected charge at a V_x voltage, and $V_1/V_2 = 2$. For $V_1 = \pm 100$ V and $V_2 = \pm 200$ V, the ion collection efficiency was better than 99.9% for both polarities, and for both ionization chambers.

3.2. Polarity Effects

The polarity effect was determined by the comparison of the collected charges, at opposite applied voltages. The highest value for the commercial ionization chamber was 0.20%, while for the homemade ionization chamber the highest value was 0.48%.

For all pairs of voltage values in the saturation test, the polarity effect did not exceed the limit of 1% [4].

3.1. Chamber Tilt Test

During this test, the ionization chamber should be rotated by at least $\pm 5^\circ$ in relation to its reference measurement position. The values obtained at each angle must not differ from 0° by more than $\pm 1.0\%$ [4]. In order to evaluate both ionization chambers, the homemade and the commercial one, they were rotated by $\pm 10^\circ$ in relation to their reference measurement position (when used in standard dosimetric procedures).

The results are shown in Figure 5. The commercial ionization chamber presented a 0.28% variation, while the homemade ionization chamber presented 0.22%. The results were all in accordance with the international recommendations [4].

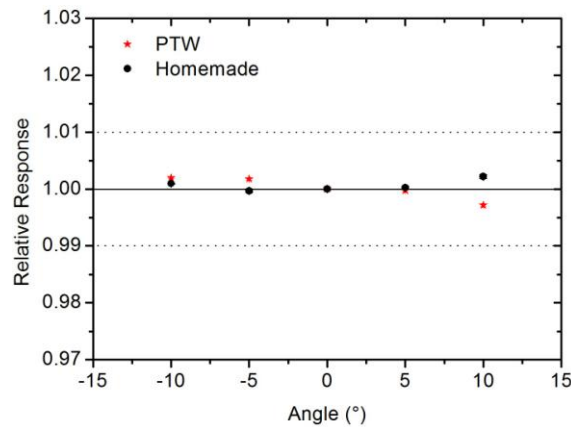


Figure 5. Results of the chamber tilt tests of the homemade and commercial ionization chambers. The dotted lines represent the international limits [4].

3. CONCLUSIONS

Both ionization chambers presented a good performance, in agreement with the international recommendations. It is also important to note that there were no significant differences, in response, between the commercial ionization chamber and the homemade ionization chamber, showing that this new dosimeter, developed at LCI, may be utilized in clinical or metrological standard applications.

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