Application of a Pencil Ionization Chamber with a 0.34 cm^3 Volume for ^{60}Co Beams: Experimental and Monte Carlo Results

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Ionization chambers are the most utilized dosimeters for precise measurements of absorbed dose, such as those required in radiotherapy. Ionization chambers are commercially available in a variety of designs for different applications. Although these commercial dosimeters are very robust and precise, they are quite expensive equipments, and there are no such Brazilian commercial detectors. With the aim to develop new ionization chambers attending international recommendations and using Brazilian low-cost materials, this work presents the study of a pencil-type cylindrical ionization chamber for routine use in ^{60}Co beams, developed at the Calibration Laboratory of IPEN. This prototype chamber is made of PMMA, has 155.0mm length, the wall material of the chamber sensitive volume is graphite coated PVC, and its collecting electrode is aluminum, with a thickness of 1.20mm. The chamber internal diameter is 6.70mm, and its wall thickness and the sensitive length are 0.26mm and 10.00mm, respectively, with a sensitive volume of 0.34cm^3. A special build-up cap was made of PMMA, with 4.0mm thickness. The main differences between the present ionization chamber and the commercially available ones that are used for dosimetry in radiotherapy are the geometry and constituent materials. This chamber is of pencil-type with its sensitive volume delimited by a thin layer of PVC, while the commercial chambers are of Farmer-type with the sensitive volume surrounded by PMMA or graphite. Following international recommendations, the characterization tests performed were: short- and long-term stability, stabilization time, saturation, ion collection efficiency, leakage current, linearity of response, angular and energy dependence. In all tests, the ionization chamber was coupled with a PTW electrometer, model UNIDOS E. The influence of the chamber body of PMMA on its response was studied using the PENELOPE Monte Carlo simulation code. For this simulation the spectrum of the ^{60}Co source utilized during the experiments is unknown; therefore, two spectra were adopted and compared: one from a bare source of ^{60}Co and one obtained from the literature [1]. The results of both spectra and the experimental data were compared by varying the thickness of the build-up caps, and the maximum difference between the simulated and experimental data was 2.2% ([1]) and 2.3% (bare source), showing that the ionization chamber was correctly simulated. The contribution of the body of PMMA was 2.4%. The characterization results of this ionization chamber tests were also compared to those of a secondary standard, PTW Farmer-type ionization chamber (TN 30002, with traceability to the PTB) used for routine calibrations at the laboratory. All results obtained were considered satisfactory, and within limits recommended internationally. Therefore, this homemade ionization chamber presents usefulness for routine dosimetric procedures in radiotherapy.

[1] MORA, G.M., MAIO, A., ROGERS, D.W.O. Monte Carlo simulation of a typical ^{60}Co therapy source. Med. Phys. v.26(11), p.2494-2502 (1999).