Desempenho de três câmaras de ionização tipo lápis (10 cm) em feixes padrões de tomografia computadorizada

Performance of three pencil-type ionization chambers (10 cm) in computed tomography standard beams.

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Resumo: O uso da tomografia computadorizada (CT) tem aumentado muito ao longo dos anos gerando assim uma preocupação com as doses que são recebidas pelos pacientes submetidos a esse procedimento. Portanto, é necessário realizar de forma contínua dosimetria desses feixes, com uma câmara de ionização do tipo lápis. Esse detector é o mais utilizado nos procedimentos dos testes de controle de qualidade nesses tipos de equipamentos. O objetivo deste trabalho foi o de realizar alguns testes de caracterização em feixes padronizados de CT, como: curva de saturação, efeito de polaridade, eficiência de coleção de íons e linearidade da resposta de três câmaras de ionização, sendo uma comercial e duas desenvolvidas no IPEN.

Palavras-chave: Dosimetria, câmara de ionização, tomografia computadorizada.

Abstract: The use of computed tomography (CT) has increased over the years, thus generating a concern about the doses received by patients undergoing this procedure. Therefore, it is necessary to perform routinely beam dosimetry with the use of a pencil-type ionization chamber. This detector is the most utilized in the procedures of quality control tests on this kind of equipment. The objective of this work was to perform some characterization tests in standard CT beams, as the saturation curve, polarity effect, ion collection efficiency and linearity of response, using three ionization chambers, one commercial and two developed at the IPEN.

Keywords: Dosimetry, ionization chamber, computed tomography.

1. INTRODUCTION

The use of diagnostic imaging making use of ionizing radiation has been shown an increase over the years, especially computed tomography (CT). It allows the obtention of images with better resolution than by other techniques, consequently it is responsible for increasing the radiation dose during the procedure. Therefore, there is an increased concern regarding the dose received by the patients undergoing this kind of imaging procedure.

For the dosimetry of CT beams, the radiation detector has a special geometry, because the tube rotates around the patient table, and it presents a uniform response to the incident radiation beam from all angles [2]. This detector receives the name of pencil-type ionization chamber. These commercial ionization chambers present a length of the sensitive volume of 10 cm, and they are used for quality control testing of the equipment.

The Calibration Laboratory of Instruments (LCI) of the IPEN has developed different kinds of ionization chambers, including a pencil-type [3,4]. However, this ionization chamber presents some differences in its construction in relation to the commercial models. The main differences were in relation to the material used in manufacturing the chamber body and the position of the BNC connector. This homemade configuration provides a low cost in its construction, and the response to the test met the internationally recommended limits, as noted in previous studies [3,4].

This work aims to show results on the characterization tests as saturation curve, polarity effect, ion collection efficiency and response linearity, for each of the pencil ionization chambers in standard CT X radiation beams at the LCI.

2. MATERIALS AND METHODS

Three pencil-type ionization chambers were tested in this work: one of them was a commercial chamber (Victoreen 660-6) called C1 (sensitive volume of 3.2 cm^3), and the other two chambers were prototypes developed at the LCI called C2 and C3; all of the ionization chambers present a sensitive volume length of 10 cm.

Table 1 shows the specifications of the ionization chambers developed at LCI, and the difference between them are based on the collector electrode material and on the dimensions of their components.

Table 1: Technical specifications of the pencil ionization chambers developed at the LCI.

Characteristics	**Specifications**	
	C2	**C3**
Collecting electrode material	Aluminum	Aluminum with graphited layer
Wall material	PVC with graphited layer	PMMA with graphited layer
Collecting electrode diameter	1.22 mm	3.20 mm
Ionization chamber diameter	6.72 mm	7.40 mm
Wall thickness	0.26 mm	0.26 mm
Sensitive volume length	10 cm	10 cm
Sensitive volume	3.40 cm^3	3.50 cm^3

The tests were performed using the reference standard CT X radiation quality at the LCI: RQT 9. This radiation quality presents the following characteristics: tube voltage of 120 kV, tube current of 10 mA, half value layer of 8.4 mmAl, additional filtration of 3.5 mmAl + 0.35 mmCu, and air kerma rate of 34.0 mGy/min.

The polarity effect for each ionization chamber should be within the internationally recommended limit of 1% [5]. The ion collection efficiency was obtained using the voltages V1= +200 V and V2= +100 V for all three ionization chambers. The results should be within the recommended limit of 95 % [5].

The X-ray system Pantak/Seifert (ISOVOLT model 160HS) of LCI/IPEN was utilized; it operates up to 160 kV.

3. RESULTS

Initially are presented the results obtained for the saturation curves, polarity effects and ion collection efficiencies for the ionization chambers. Figure 1 shows the saturation curves.

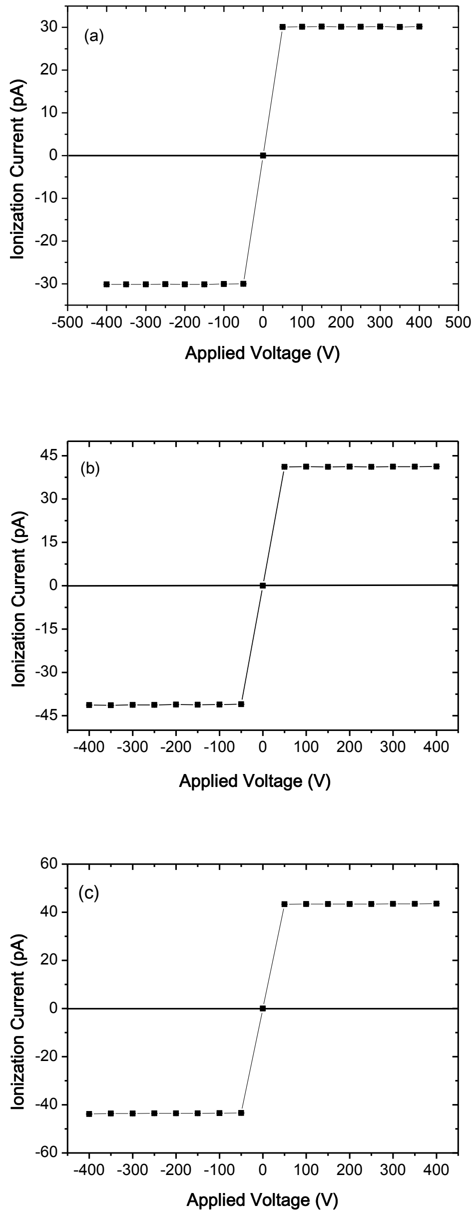

Figure 1: Saturation curves of the ionization chambers for the radiation quality RQT 9: (a) C1; (b) C2; (c) C3. The maximum measurement uncertainty was 0.59%.

It is possible to observe that all three pencil-type ionization chambers present good results for the saturation curves, but they reach saturation at different values, because of their slightly different volumes and constituent materials.

The results for the polarity effects and ion collection efficiencies were obtained through the saturation curves, and they can be seen in table 2.

Table 2: Polarity effects and ion collection efficiencies for the ionization chambers.

Ionization chamber	Polarity effect (%)	Ion collection efficiency (%)
C1	0.32	99.97
C2	0.57	99.99
C3	0.29	99.98

As can be observed, the three ionization chambers with a sensitive volume length of 10 cm presented results within the internationally acceptable limits. The operating voltage used for all characterization tests for all three ionization chambers was chosen as +100 V.

The response linearity obtained for each ionization chamber in the standard CT reference radiation quality of LCI is presented in figure 2. This test was performed varying the tube current from 2 mA to 18 mA in steps of 2 mA, in order to obtain different air kerma rates, and each response was normalized for 2 mA, in the case of the commercial Victoreen ionization chamber and also for the homemade ionization chambers.

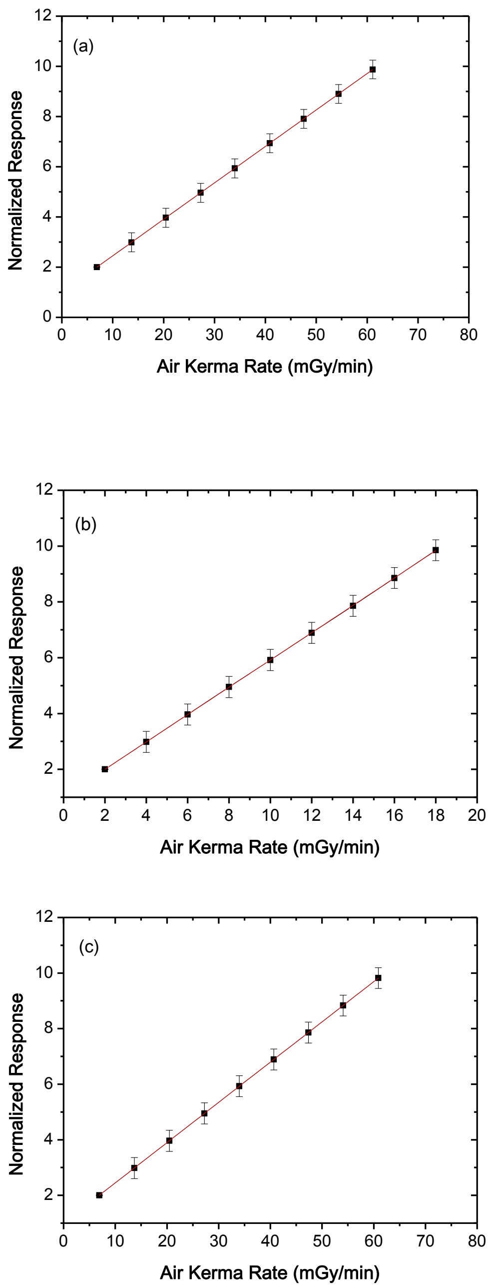

Figure 2: Linearity of response to quality RQT 9 of the ionization chambers: (a) C1; (b) C2; (c) C3. The linear correlation coefficient in all cases is R^2=1.000.

As can be observed, all three ionization chambers with a sensitive volume length of 10 cm presented the linear correlation coefficients of 1.000, showing that the ionization chambers have a linear response, as required by the quality control program.

4. CONCLUSIONS

The test results of the commercial ionization chamber (10 cm) were all within the internationally recommended limits. The homemade ionization chambers (10 cm) presented also results within the limits, although of their differences in size and construction material.

5. REFERENCES

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