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Testing an extrapolation chamber in computed tomography standard beams

M C Castro, N F Silva and L V E Caldas

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP) - Av. Professor Lineu Prestes, 2242 – CEP:05508-000 São Paulo, SP.

E-mail: maysadecastro@gmail.com

Abstract: The computed tomography (CT) is responsible for the highest dose values to the patients. Therefore, the radiation doses in this procedure must be accurate. However, there is no primary standard system for this kind of radiation beam yet. In order to search for a CT primary standard, an extrapolation ionization chamber built at the Calibration Laboratory (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN), was tested in this work. The results showed to be within the international recommended limits.

1. Introduction

The computed tomography (CT) diagnostic exams are responsible for the highest dose values to the patients. The radiation doses in this procedure have to be determined with the highest possible precision and accuracy. However, there is no primary standard system for this kind of radiation beam. So, it was decided to use an extrapolation ionization chamber, built at the Calibration Laboratory (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN) to establish a CT primary standard [1,2].

An extrapolation chamber is a parallel-plate ionization chamber that allows the variation of its sensitive air volume. Usually, this ionization chamber is utilized in beta radiation dosimetry [1], but this chamber was already used for low-energy radiation beams too, and it showed results within the international recommended limits [2-4].

The aim of this work was to performe some of the main characterization tests (stabilization time, leakage current and linearity of response) in two different chamber depths (interelectrode distances) of the extrapolation chamber in standard X-ray beams established for computed tomography at the LCI. When the depth is varied there are different sensitive volumes; therefore it is possible to decide which chamber depth is the best for standard CT beams.

2. Materials and Methods

The measuring system used in this work was an extrapolation chamber with a collecting electrode of 30 mm in diameter, entrance window made of aluminized polyethylene terephthalate and a graphited guard ring. This ionization chamber was developed by Dias and Caldas [1,2] at the LCI.

The characterization tests performed in this work were stabilization time, leakage current and linearity of response for the extrapolation chamber in two different depths (0.75 mm and 1.00 mm). For the stabilization time and leakage current, a ^{90}Sr + ^{90}Y control source (33 MBq) was utilized. For the linearity of response test the X-ray system Pantak/Seifert (ISOVOLT model 160 HS) operating up to 160 kV was utilized. Table 1 shows the CT radiation qualities established at the LCI.

Table1. Characteristics of the CT standard beams based on the IEC [5].

Radiation Quality	Tube Voltage (kV)	Tube Current (mA)	Air Kerma Rate (mGy/min)
RQT 8	100	10	22.0
RQT 9	120	10	34.0
RQT 10	150	10	57.0

For the stabilization test of the ionization chamber, the measurement standard deviation must not exceed ± 2% when comparing the response ionization current obtained in 15 min and 60 min [5].

For the leakage current test of the ionization chamber, the measurement standard deviation obtained before and after irradiation must not exceed 5 % [5].

The linearity of response of the extrapolation chamber must present a linear curve, so the correlation factor needs to be close of 1.0 (R^2= 1.00).

The uncertainties of type A and type B were determined, with the combined uncertainty of factor k = 2 when necessary.

3. Results and Discussion

Initially are presented the results obtained for the stabilization test in both depths. These results are shown in Table 2.

Table 2. Stabilization time of the extrapolation chamber response in two different depths.

Depth (mm)	Stabilization Time (%)
0.75	0.17
1.00	0.15

The results shown for the stabilization time of the extrapolation chamber in both depths are within the internationally acceptable limits [5].

For the leakage current tests the results obtained before and after irradiation for both depths can be seen in Table 3.

Table 3. Leakage current of the extrapolation chamber response in two different depths.

Depth (mm)	Before Irradiation (%)	After Irradiation (%)
0.75	2.39	3.30
1.00	3.51	0.94

The results obtained for the leakage current of the extrapolation chamber response in both depths are within the recommended limits [5].

For the linearity of response, the results obtained can be seen in Figures 1 and 2: the linearity of response for the extrapolation chamber in the respective chamber depths of 0.75 mm and 1.00 mm.

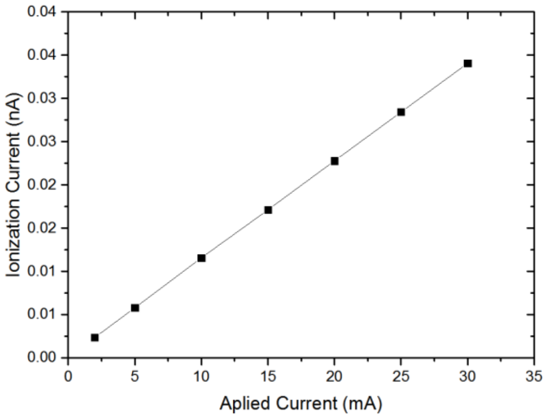

Figure 1. Linearity of response curve of the extrapolation chamber in the reference radiation quality (RQT 9) in the chamber depth of 0.75 mm. The maximum measurement uncertainty was 0.0004 %.

As can be observed in Figure 1, the correlation factor for the linearity of response curve in depth of 0.75 mm was 0.9999.

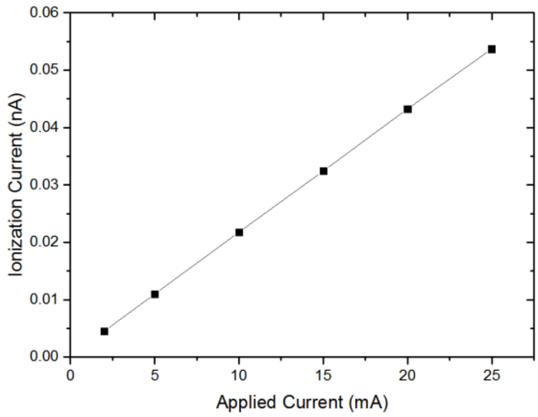

Figure 2. Linearity of response curve of the extrapolation chamber in reference radiation quality (RQT 9) in depth of 1.00 mm. The maximum measurement uncertainty was 0.0004 %.

As observed in Figure 2, the correlation factor for the linearity of response curve in profundity of 1.00 mm was 0.9999.

4. Conclusion

The results obtained for the characterization tests of the homemade extrapolation chamber in computed tomography standard beams were in agreement with the international recommendations.

When analyzing the results obtained in the two different chamber depths it is possible to observe that for the computed tomography beams the depth of 1.00 mm presented the best results.

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