International Joint Conference Radio 2019

Some characterization tests for an extrapolation chamber in CT standard beams in a specific chamber depth

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Introduction

The use of Computed Tomography (CT) for diagnostic images has been growing due to technological advances of this equipment. Therefore, there is a concern regarding the dose received by the patients undergoing this procedure, and this procedure needs to be performed with the highest precision and accuracy possible.

The radiation detector used for CT beams is a pencil-type ionization chamber. However, there is no primary standard system for this kind of radiation beam. In this work a homemade extrapolation chamber was used to establish a CT primary standard [1]. This detector was tested for low-energy radiation beams and showing results within the internationally acceptable limits [2].

This work had the objective to study the response stability of an extrapolation chamber, as well as obtaining the energy dependence and the angular dependence in standard CT beams of the Calibration Laboratory of IPEN (LCI).

Materials and Methods

The extrapolation chamber has a collecting electrode of 30 mm in diameter, the entrance window is made of aluminized polyethylene terephthalate with density of 0.84 mg/cm², and the collecting electrode and guard ring are made of graphite; this chamber was developed at the LCI [1].

For the short and medium-term stability study of the extrapolation chamber, a ^{90}Sr + ^{90}Y control source (33 MBq) was utilized. For the short-term stability test the standard deviation must not exceed 1%. For the medium-term stability test the standard deviation should not exceed 2% [3].

In order to obtain the energy dependence and the angle dependence of the extrapolation chamber, an X-ray system Pantak/Seifert (ISOVOLT model 160HS) was utilized, which operates up to 160 kV. Table 1 presents the CT radiation qualities at the LCI.

Table 1: Characteristics of the CT standard X radiation qualities at the LCI, based on the IEC 61267 report [4].

Radiation Quality	Tube Voltage (kV)	Tube Current (mA)	HVL (mmAl)	Air Kerma Rate (mGy/min)
RQT 8	100	10	6.9	22.0
RQT 9 †	120	10	8.4	34.0
RQT 10	150	10	10.1	57.0

† Reference CT radiation quality at LCI/IPEN
HVL: Half-Value Layer

For the energy dependence, the calibration coefficient and the correction factor are obtained and they must not exceed 5 % [3]. For the angular dependence the recommendation based on the IEC 61674 report, the standard deviation should not exceed 3 % [3].

Results

The results for the short- and medium-term stability tests for the extrapolation chamber are presented. Figure 1 shows the response normalized to the mean value of the first ten measurements of the extrapolation chamber. The result for the short-term stability test was 0.04 %, in accordance with IEC 61674 [3].

Figure 1: Medium-term stability for the extrapolation chamber; the maximum uncertainty of the measurements was 0.61%.
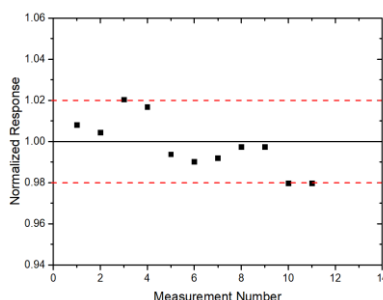

As observed in Figure 1, the medium-term stability of the extrapolation chamber is within the recommended limits [3]. The energy dependence for the extrapolation ionization chamber in CT radiation qualities can be seen in Table 2.

Table 2: Energy dependence of the extrapolation chamber.

Radiation Quality	Calibration Coefficient (mGy/pC)	Correction Factor
RQT 8	0.0200 ± 0.0003	0.9348 ± 0.0002
RQT 9	0.0214 ± 0.0003	1.0000 ± 0.0002
RQT 10	0.0229 ± 0.0003	1.0720 ± 0.0002

From Table 2, the energy dependence is shown within the internationally acceptable limits [3]. Figure 2 shows the angular dependence and the response normalized for the central position for the extrapolation chamber.

Figure 2: Angular dependence of the extrapolation chamber response; the maximum uncertainty of the measurements was 0.04 % in the radiation quality RQT 10.
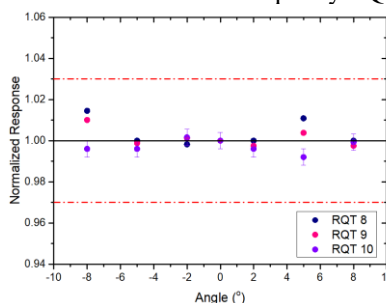
The results obtained for the angular dependence of the extrapolation chamber response are within the recommended limits as can be seen in Figure 2 [4].

Conclusion

The results obtained for four characterization tests of the homemade extrapolation chamber for the specific chamber depth of 1.25 mm in standard computed tomography beams were in agreement with the international recommendations. The decision about the extrapolation chamber depth for the aluminum collecting electrode was appropriate.

References

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