

TESTING A RING-SHAPED IONIZATION CHAMBER IN STANDARD BETA RADIATION

Maíra T. Yoshizumi and Linda V. E. Caldas

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)

Av. Professor Lineu Prestes 2242

05508-000 São Paulo, Brazil

mairaty@ipen.br

lcaldas@ipen.br

ABSTRACT

A ring-shaped ionization chamber, developed at Instituto de Pesquisas Energéticas e Nucleares, was tested in standard beta radiation fields. This ionization chamber was primarily developed to be used as a monitor chamber in X-ray diagnostic radiology beams. It has a large sensitive volume and parallel-plate aluminium electrode. Its entrance window is made of a thin aluminized polyester foil, which allows the collection of electrons. The ring-shaped monitor chamber was already tested in X radiation beams, showing a good performance. The aim of this work was to verify the applicability of the ionization chamber for beta radiation field dosimetry at calibration distances.

1. INTRODUCTION

The increasing utilization of ionizing radiation and the way this radiation is being used is a worrying issue. Therefore, international organizations have published recommendations of error limits and safety principles on radiation applications, as for instance in references 1-4.

For X-radiation, one recommendation is the use of monitor chambers to assure the dose delivery [3]. Usually, monitor chambers are large volume parallel-plate ionization chambers but a thimble chamber (Farmer type chamber) can be used as well [5]. The difference is that parallel-plate chambers are used in direct beams while the thimble chambers are positioned in the penumbra radiation region.

A ring-shaped ionization chamber was developed at Instituto de Pesquisas Energéticas e Nucleares thinking of these two kinds of monitor chambers. The ionization chamber is parallel-plate type, with a large sensitive volume, and it is fixed in front of the X-ray tube, but only measuring the penumbra radiation. The chamber characteristics in X-radiation beams were described in a previous work [6].

In this work, the ring-shaped ionization chamber was tested in standard beta radiation fields. These tests were performed to verify the applicability of this ionization chamber utilization for beta radiation beam dosimetry.

2. MATERIALS

The ring-shaped ionization chamber used in this work was described in a previous work [6]. This chamber has a sensitive volume of approximately 200 cm³, and it presents a 6 cm diameter central hole. It was developed to be used as a monitor chamber in X-rays beams, and it is showed in Fig. 1. The ring-shaped chamber was used with an electrometer, *Physikalisch-Technische Werkstätten*, PTW, model UNIDOS.



Figure 1. The ring-shaped ionization chamber.

The tests were performed using a standard beta radiation system, *Beta Sekundär Standard BSS2*, AEA Technology QSA. This system has three beta radiation sources: ⁹⁰Sr+⁹⁰Y, ⁸⁵Kr and ¹⁴⁷Pm. These sources were calibrated at the primary laboratory, *Physikalisch-Technische Bundesanstalt* (PTB), Germany. The radiation sources characteristics are described on Table 1.

Table 1. Beta radiation sources characteristics (BSS2 system) for the calibration date: November 19, 2004.

Radionuclide	Nominal Activity	Medium Energy (keV)	Calibration Distance (cm)	Flattening Filter	Absorbed Dose Rate in Air (μGy.s ⁻¹)
⁹⁰ Sr+ ⁹⁰ Y	460 MBq	800	11.0	No	111.13±1.84
			20.0	No	34.87±0.60
			30.0	No	15.47±0.26
			30.0	Yes	10.14±0.17
			50.0	No	5.53±0.10
⁸⁵ Kr	3.7 GBq	251	30.0	Yes	41.68±0.66
¹⁴⁷ Pm	3.7 GBq	60	20.0	Yes	11.37±0.27

3. RESULTS

3.1. Response stability test

The response stability test was performed in a previous work [6] using a $^{90}\text{Sr}+^{90}\text{Y}$ beta radiation check source device. The ring-shaped ionization chamber response presented a variation of 0.4% and 0.7% for the short- and medium-term stability tests. International recommendations limits for these tests are $\pm 3\%$ and $\pm 2\%$, respectively [1]. The leakage current was negligible during all the test period. Fig. 2 shows the medium-term stability test results [6].

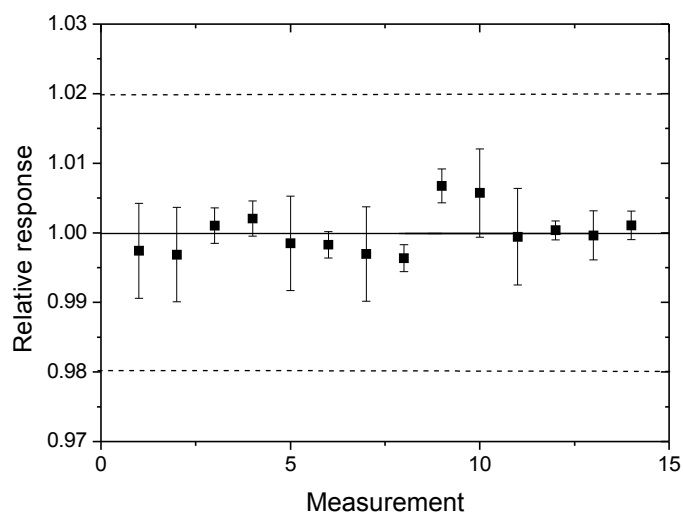


Figure 2. Medium-term stability of the ring-shaped ionization chamber using a beta radiation check device [6]. The dashed lines show the limits recommended by the IEC publication [1].

3.2. Field size dependence

The beta radiation system BSS2 presents a field size diameter of approximately 12 cm at 30 cm from the $^{90}\text{Sr}+^{90}\text{Y}$ source. When the ring-shaped ionization chamber was positioned at this distance, its sensitive volume was exposed. It means that, except for the 11 cm source-detector distance, the aluminum collecting electrode was exposed producing scattered radiation. This fact is showed in Fig. 3.

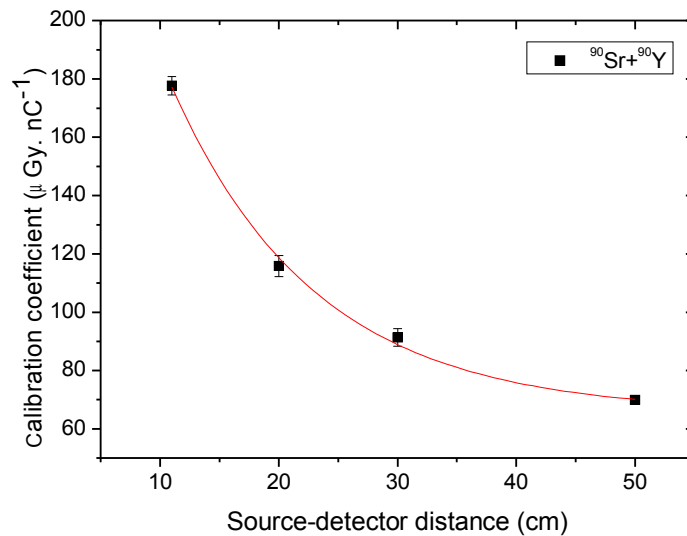


Figure 3. Field size dependence of the ring-shaped monitor chamber.

As can be seen in Fig. 3, the calibration coefficient of the monitor chamber decreases as the radiation field increases; this response behavior was expected. This fact occurs because the scattered radiation produced by the collecting electrode contributes on the final chamber response. In Fig. 3, only the measurements without a flattening filter were considered.

3.2. Energy dependence

The ideal condition to perform the energy dependence test would be exposing the monitor chamber at the same conditions using different radiation sources. But, the calibration certificate of the beta radiation sources is restricted to some conditions. Because of that, the three exposure conditions using the flattening filter had to be considered. The energy dependence of the monitor chamber can be seen in Fig. 4.

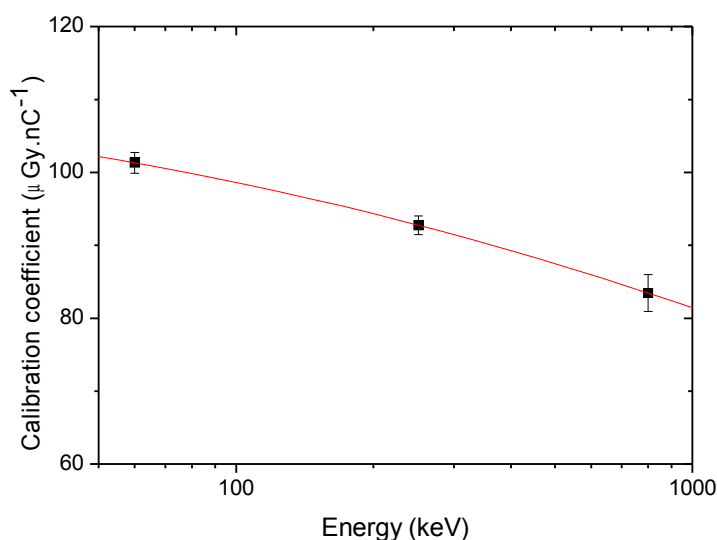


Figure 4. Energy dependence of the ring-shaped ionization chamber.

In Fig. 4, it is possible to verify that the energy dependence is 21%. It is necessary to remember that the calibration distance for the ^{147}Pm source is 20 cm, while the other sources are calibrated at 30 cm. As showed in Fig. 3 the field size does interfere in the chamber response. So, actually, the energy dependence of the ring-shaped ionization chamber is lower than 21%.

4. CONCLUSIONS

In this work, the field size and energy dependences of a ring-shaped monitor ionization chamber in beta radiation fields were tested. The field size dependence, as expected, showed an exponential dependence. This dependence is a result of the increasing scattered radiation from the collecting electrode as the field size rises. The energy dependence was studied for the three available beta radiation sources. These sources cover an energy range from 60 to 800 keV. The energy dependence obtained was 21%.

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