2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
Associação Brasileira de Energia Nuclear - ABEN
ISBN: 978-85-99141-02-1

EVALUATION OF AN IONIZATION CHAMBER RESPONSE AT SMALL DISTANCES DURING DOSIMETRY OF GAMMA RADIATION BEAMS

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ABSTRACT

The beam dosimetry measurements of a gamma irradiator, utilized for calibration of mainly portable radiation monitors, at the Calibration Laboratory of IPEN, have been taken between the source-instrument distance of 1m and 4m. Due to the source decay and instruments with higher dose rate ranges, calibrations at distances smaller than 1m are necessary. For this purpose, a 30cm^3 ionization chamber calibrated against a secondary standard system was utilized. The use of this chamber is appropriate, because it can be totally irradiated. The behavior of this ionization chamber was studied in terms of: repeatability, stability and current leakage, using a ^{90}Sr+^{90}Y source. The repeatability test presented uncertainties lower than ±0.5%. Analyzing the stability results, the variation did not exceed ±1.0%. The current leakage did not exceed 0.5% of the reference value. The measurements at the irradiator beams were taken at smaller distances than 1m (in steps of 10cm). The distance square inverse law was verified for both ^{137}Cs and ^{60}Co sources; the variations did not exceed ±5%, according to the ISO 4037-1 standard.

1. INTRODUCTION

The Calibration Laboratory of IPEN offers calibration services for portable radiation monitors using a gamma irradiator with ^{137}Cs and ^{60}Co radioactive sources. The beam dosimetry measurements are taken annually between the source-instrument distance of 1m and 4m. However, due to the source decay and instruments with higher dose rate ranges, calibrations at distances smaller than 1m are sometimes necessary [1]. Thus long irradiation time intervals can be avoided.

The beam dosimetry measurements are usually taken using the laboratory secondary standard system. Nevertheless, this ionization chamber has a relatively large size, which hinders the complete irradiation when positioned closer to the source.

Based on this need, a 30cm^3 cylindrical ionization chamber was utilized for the dosimetry measurements at small distances. Thereto, the ionization chamber behavior was studied in terms of: repeatability, stability and current leakage tests, using a control source [2]. It was also calibrated against the secondary standard system.

2. METHODOLOGY AND RESULTS

This work required the following equipments: a PTW cylindrical ionization chamber, model 23361, 30cm^3 of sensitive volume, calibrated against the secondary standard system (composed by 1 liter ionization chamber, PTW, model LS-01, with traceability to the National Laboratory of Metrology of Ionizing Radiations, Brazil), coupled to a PTW electrometer (model Unidos); a $^{90}Sr+^{90}Y$ control source with nominal activity of 33MBq (1988); a gamma irradiator Buchler, model OB85, with ^{137}Cs and ^{60}Co radioactive sources, with nominal activities of 740GBq and 37GBq (1995), respectively; and 3 lead absorber filters with purity of 99.9% (with 2.2cm, 1.8cm and 2.0cm of thickness).

Initially, the behavior of this ionization chamber was studied to assure the possibility of its use for the beam dosimetry measurements. Then the irradiator beam dosimetry measurements were taken.

2.1. Ionization Chamber Behavior

Repeatability was the first test made with the ionization chamber behavior study. This test consists of positioning the $^{90}Sr+^{90}Y$ control source on the chamber using a special acrylic support (assuring the reproducible geometry). Then, series of ten consecutive integrated charge measurements were taken. This procedure was repeated 12 times, and all series presented uncertainties lower than ±0.5%.

The stability test is the comparison of the repeatability series variation with the time. All values were normalized to the mean value of the 10 first results. This variation did not exceed ±1.0%. These results are showed in Figure 1:

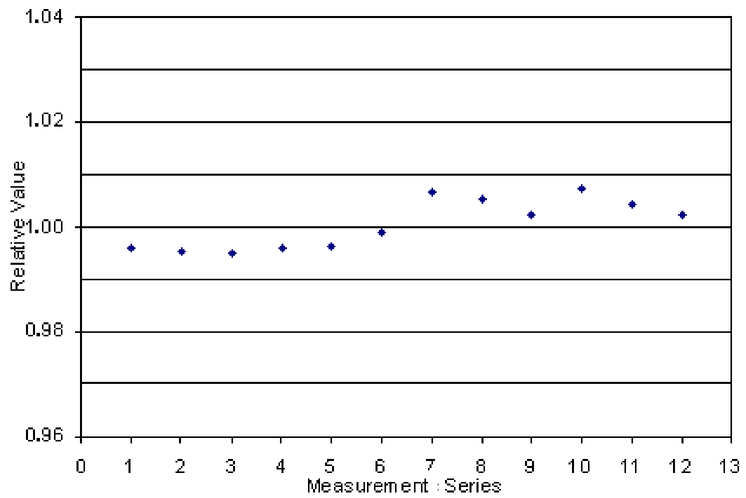


Figure 1. PTW ionization chamber stability, using a PTW $^{90}Sr+^{90}Y$ check source.

The current leakage test consists of the total detector current flowing at the operating bias in the absence of radiation. The current leakage did not exceed 0.5% of the reference value produced during the time of measurement.

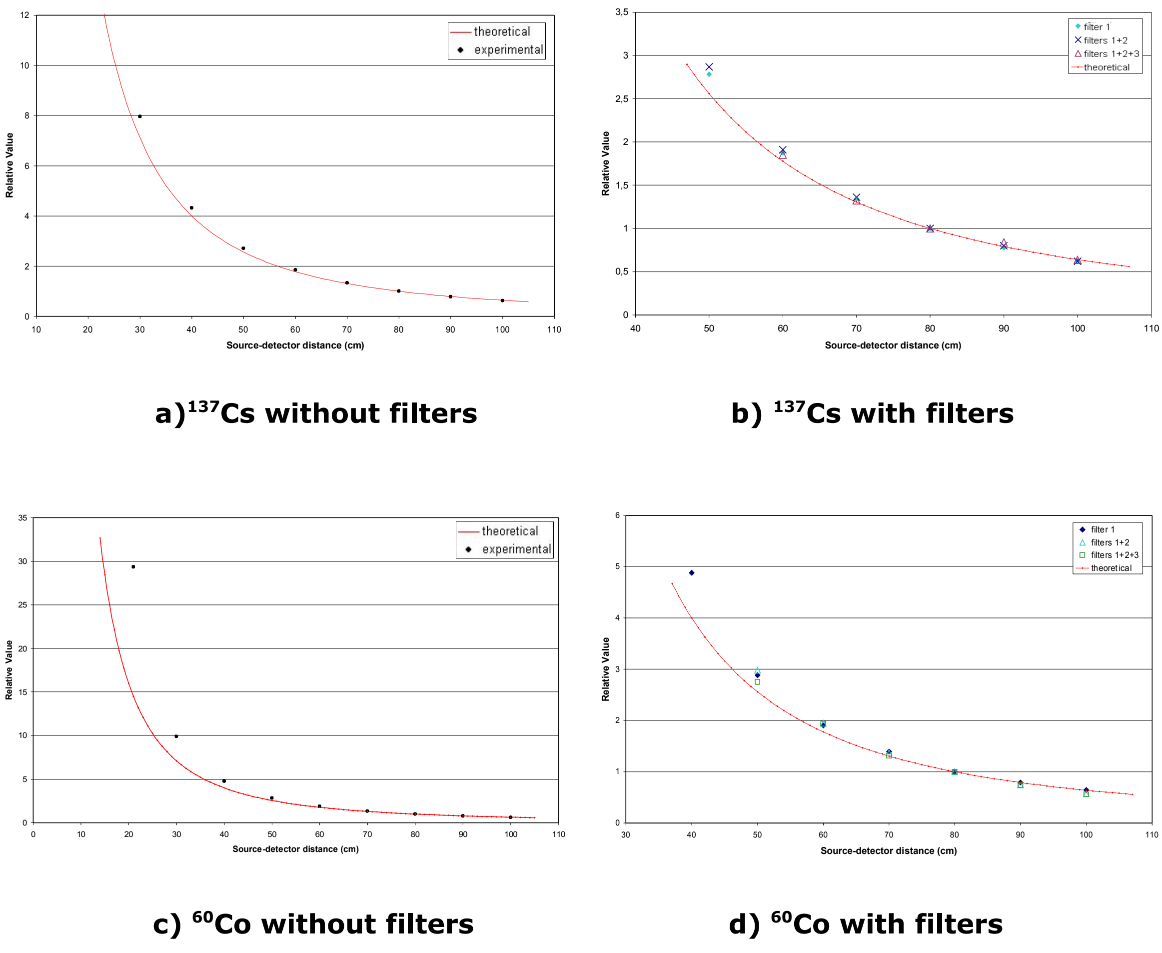
These test results are in agreement with the ISO 4037-2 standard [2]. Therefore, the use of this chamber for the beam dosimetry measurements is appropriate.

2.2. Beam Dosimetry Measurements

At the irradiator, the measurements were taken at distances smaller than 1m for both ^{137}Cs and ^{60}Co beams. The chamber position was changed in steps of 10cm. At each position, 6 measurements were taken. Initially, this procedure was applied without absorber filters. Then, it was repeated adding the absorber filters.

The beam behavior at small distances showed the expected results, according to the ISO 4037-1 standard [1]. For both ^{137}Cs and ^{60}Co source beams, the distance square inverse law was verified with variation lower than 5% between 40cm and 100cm. However, the measurements made between 10cm and 40cm diverged from the theoretical values (calculated by the distance square inverse law). These discrepancies reached 10% at 30cm from the source; 17% at 20cm; and 20% at 10cm. According to the ISO 4037-1 standard, this uncertainty increases due to the dose gradient raise caused by electronic equilibrium distortions at small distances.

The data obtained for the measurements and the theoretical curves (based on the distance square inverse law) are showed in Figure 2.



a)^{137}Cs without filters **b) ^{137}Cs with filters**

c) ^{60}Co without filters **d) ^{60}Co with filters**

Figure 2: Attenuation curves of the gamma radiation (^{137}Cs and ^{60}Co) beam intensity in relation to the source-detector distance, with and without absorber filters (experimental and theoretical values)

3. CONCLUSIONS

The ionization chamber behavior tests showed results within the international recommendations. Therefore, the use of this ionization chamber for the beam dosimetry measurements was appropriate. In this work the distance square inverse law was verified at source-detector distances smaller than 1m but larger than 40cm. Therefore it is possible to calibrate radiation monitoring instruments at distances smaller than 1 m using the ^{137}Cs and ^{60}Co sources. However, it is necessary to assure that the whole instrument to be calibrated is in the radiation field.

ACKNOWLEDGMENTS

The authors acknowledge the partial financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes), Brazil.

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