Influence of the radioactive source position inside the well-type ionization chamber

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Abstract: The activimeter, instrument used in radionuclide activity measurement, consists primarily of a well type ionization chamber coupled to a special electronic device. Its response, after calibration, is shown in activity units (Becquerel or Curie). The goal of this study is to verify radioactive source position influence over activity measured by this instrument. Radioactive sources measurements were made at different depths inside the ionization chamber well. Results showed maximum variation of -23 %, -28 % and -15 % for ^{57}Co, ^{133}Ba and ^{137}Cs, respectively.

Keywords: activity meter; nuclear medicine; control quality

1. INTRODUCTION

Activimeters are essential instruments for a nuclear medicine service to operate. This is the measurement equipment used to verify the activity of radiopharmaceutical used in therapy and/or diagnostic procedures [1].

They consist basically of a well-type ionization chamber, filled with high-pressured gas, in which a radioactive material can be introduced for measurement. The material activity is measured in terms of the electrical current produced when the emitted radiation interacts with the gas. The ionization chamber has two co-axial cylindrical electrodes where a bias voltage is applied [2].

A lead shielding around the chamber provides protection against radiation hazards and reduces background radiation measurement [2]. Activimeters are normally calibrated with the lead shielding, which eliminates incorrect measurements due to the shield use [3].

Furthermore this equipment comes with accessory used to guarantee geometry reproducibility, designed to accommodate both syringes and vials, and is made of acrylic which attenuation and scattering effects are almost zero. Usually this source holder keeps the radioactive source close to the well chamber's bottom [3].

Activimeters must be calibrated using standard radioactive sources provided by a standard laboratory (direct calibration) or by comparison using reference equipment (indirect calibration) [4].

Instrument readings depend on measurement conditions, such as source geometry, material, homogeneity, syringe/vial wall thickness, volume and its position inside the chamber [5]. A small change in one or more characteristics may cause a substantial activity measurement variation, especially for low-energy gamma emitters [3]. To guarantee the activity meters proper operation a quality control procedure is necessary [6].

The goal of this study is to verify the radioactive source position influence over activity measurements changing source position inside the well chamber,

2. MATERIALS AND METHODS

In this study three sealed reference radioactive sources were used: ^{133}Ba, ^{137}Cs and ^{57}Co. Tests were performed in two Capintec activity meters: CRC-15BT model, presenting traceability to University of Wisconsin Accredited Dosimetry Calibration Laboratory (UWADCL), USA, and one NPL-CRC model, traceable to National Physical Laboratory (NPL), England, which is the reference equipment at the Instruments Calibration Laboratory (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP), and for this reason it periodically goes through quality control procedures [7-9].

Reference activities were obtained placing reference sources at the regular measurement position (figure 1).

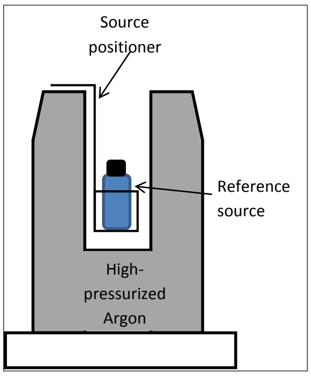

Figure 1.Reference activities were taken with the source placed at the regular measurement position.

The reference source position inside the well chamber was changed in depth, 2 by 2 cm, from 0 cm (regular measurement position) to 14 cm for NPL-CRC and 8 cm for CRC-15BT.

Ten measurements were taken for each position, and the activity values obtained were compared with the reference values.

3. RESULTS AND DISCUSSIONS

The relative responses for each reference source, at different depths, are presented in figure 2 (NPL-CRC) and figure 3 (CRC-15BT).

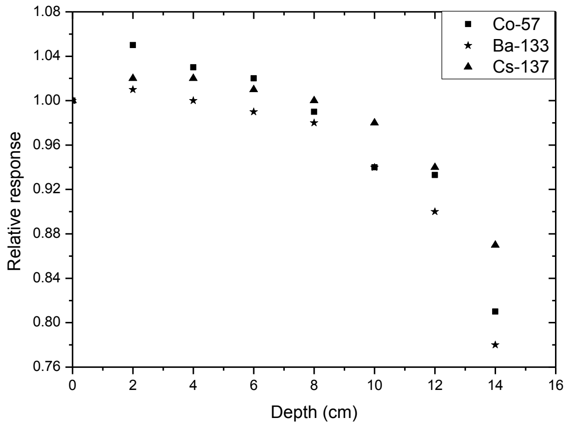

Figure 2. Relative response for each reference source, at different depths (NPL-CRC). Uncertainties were smaller than 2 %.

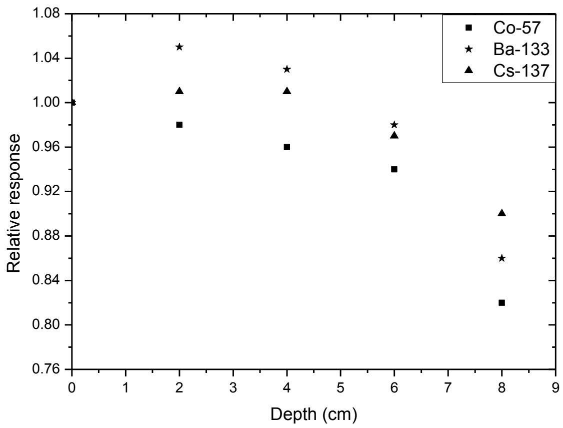

Figure 3. Relative response for each reference source at different depths (CRC-15BT). Uncertainties were smaller than 2.0 %.

In tables 1 and 2 the measurement variation between reference position and different depths are presented, for NPL-CRC and CRC-15BT, respectively. Uncertainties were smaller than 3.0 %, and negative values mean that the measurement at the given depth was lower than the reference.

Table 1. Response variation between reference position and other depths for NPL-CRC.

Depth (cm)	Variation with reference position (%)		
	Co-57	Cs-137	Ba-133
2	4.7	1.9	0.6
4	2.7	2.0	0.1
6	2.1	1.3	-0.8
8	-1.4	0.0	-2.2
10	-6.0	-2.4	-6.1
12	-7.2	-6.3	-11
14	-23	-15	-28

Table 2. Measurement variation between reference position and different depths for CRC-15BT.

Depth (cm)	Variation with reference position (%)		
	Co-57	Cs-137	Ba-133
2	-1.8	0.7	4.4
4	-4.2	0.7	3.2
6	-6.7	-3.6	-2.4
8	-21	-11	-16

Results show a maximum variation of -23 % (^{57}Co), -15 % (^{137}Cs) and -28 % (^{133}Ba), for NPL-CRC, and -21 % (^{57}Co), -11 % (^{137}Cs) and -16 % (^{133}Ba), for CRC-15BT. In the case of the reference system (NPL-CRC) it is possible to realize that the regular positions underestimate the activity measurement considering that the values are higher when the vial is above the regular position until 6 cm for Co-57 and Cs-137.

Major variations are obtained when reference source is placed at 14 cm (NPL-CRC) and 8 cm (CRC-15BT), what is expected, since the radioactive source is almost out the well chamber, in these last positions.

4. CONCLUSIONS

Measurements were made changing radioactive source depth from zero (reference point) to 14 cm (NPL-CRC) and 8 cm (CRC-15BT). Both instruments presented activity measurement variations in different depths. In the case of the reference system (NPL-CRC)

Results showed that a small mistake in radioactive source position inside the chamber can cause a significant activity measurement error, which means that carelessness in this kind of procedure may result in higher or lower radiopharmaceutical activity measurement, thereby impairing medical exam and patient.

It is necessary to determine the best position inside the well to each activimeter because the regular position determined by the source positioner can over or underestimate the obtained values.

5. ACKNOWLEDGEMENTS

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