Application of patent BR102013018500-0 in well type ionization chambers

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Abstract: The definition of the radioactive sample position in a well type ionization chamber is the largest source of uncertainty in the measurement of quantity activity. The determination of this parameter in two activimeters helped to improve their accuracies, from 2.62 and 2.59% to 3.87 and 1.74%, with and without the use of the positioning device, concluding, that with their use has reached an uncertainty of $U = 0.2276$ and 0.2677 % ($k = 2$) 95.45%.

Keywords: metrology, ionization chamber, ativímetro, uncertainties.

1. INTRODUCTION

The determination of the radioactivity source activity, needs to be better studied, if the spatial dependence been considered sample radiation in the detector. The instrumentation in charge of these measurements is the activimeter, it should be aided by systems compatible in determining the greatness activity.

The detector spatial dependence is derived from the radioactive sample placement in and established both by use of different geometries and materials [1], and by the different volumes and densities [2], resulting directly in its sensitivity, being necessary to use correction factors for efficiency to avoid biased processes, that could cause sub or super dosage for a clinical or therapeutic procedures, producing unwanted impacts to biological organisms [3,4].

The sample position within the ionization chamber is one of the main factors affecting the measurements accuracy of the greatness activity [5], and this positioning variation can be caused by sources different geometries and volumes [6].

The correlation shown between the two input quantities directly uncertainties related influence to its accuracy [7], so the spatial dependence is determining the uncertainties obtained for the results sensitivity and accuracy [8].

The activimeters are set by manufacturers using standard procedures, with ^{137}Cs, ^{133}Ba and ^{57}Co tracked sources, with volumes and different characteristics to those used daily in nuclear medicine services. These instruments are traded with an accessory used for the radioactive samples insertion in the detector, with different regions to different positions, depending on the manufacturer, providing a blurring of the ideal measurement point.

In order to present a response to the amount of radiation administered to patients, and considering the accuracy fundamental for measurements, we tested the device developed in patent BR102013018500-0, to assess the associated uncertainties activity.

2. EXPERIMENTAL ARRANGEMENT

The device [9], shown in figure 1, was produced with low scattering material for determining the depth coefficient in activimeters. A conical base is fixed by a screws system positioned in the detector recess and it is capped in the center by bubble level and a dial indicator. There is a rail system, which enables the graduated sliding rod, jogging longitudinally and transversely, fixed by screws. The sliding rod has a handle on its upper end, and in the lower one, a holder sources where radioactive samples are deposited.
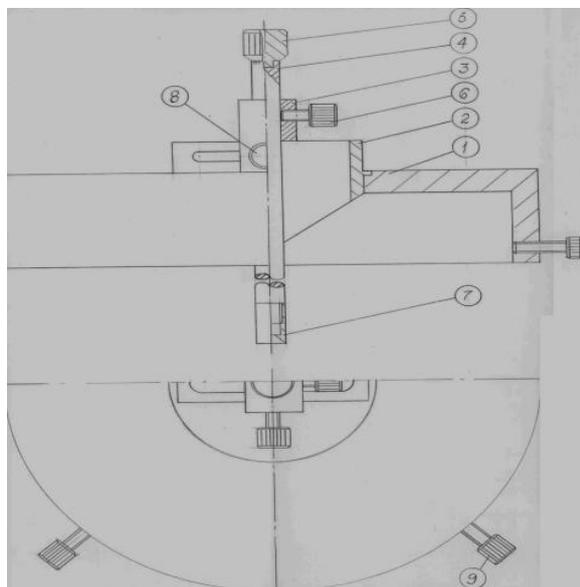
Figure 1: Project Design, presenting the view of the longitudinal and cross section of the device, consisting of nine parts, as follows: (1) Mounting base for coupling to the activimeter, that supports the rail system and sliding-stem, (2) Conical rail in shape which is positioned a sliding rod for transverse and longitudinal axes movement, (3) Base of the tracks where sliding rod moves, (4) graduated sliding rod (5) to handle moving the sliding rod (6) Screw fixer ofl slide rod (7) Holder sources (8) Screw fixer for tracks base (9) Screws to coupling base.

Was used a technetium-99m source (^{99m}Tc), the monoenergetic gamma emitter radionuclide widely used in nuclear medicine procedures. The radioactive volume of the sample was obtained by dripping sodium pertechnetate ($Na^{99m}TcO_4^-$), with hypodermic

needle with 25.0 mm length by 0.7mm diameter aided. The measured activity in a reference activimeter was considering the radioactive decay.

The device was used in two ionization chamber (IC), with sensitive volume of 3.12 cm3 and 3.16 cm3 respectively for detectors 1 and 2. Both IC were sealed and filled with argon gas submitted to 1.2 Pa E5 of pressure.

Input quantities of type A and B were defined according to the Guide to the expression of uncertainty in measurement [10], and later determined the combined and expanded uncertainties as described by Peixoto [11,12], adopting a confidence level of 95.45% [13].

3. EXPERIMENTAL PROCEDURE

The device (figure 2), leveling with the bubble level device. Deposit the radioactive source in the carrier sources and determine its volume and activity at the time of measurement.

Figure 2: The black arrows show the device mounted on top of the both IC, demonstrating the fit and system functionality. The convenience and ease of handling device, allows the procedure to be performed in the activimeters origin sites.

Calculate the initial activity based on data obtained directly from the radiopharmaceutical

supplier, and subsequently validate it with measurement referenced activimeter.

Fix the holder sources on the sliding rod and position it like position 1, recess of the detector background, moving it longitudinally upward, at intervals of one centimeter, performing three measurements every fifteen seconds.
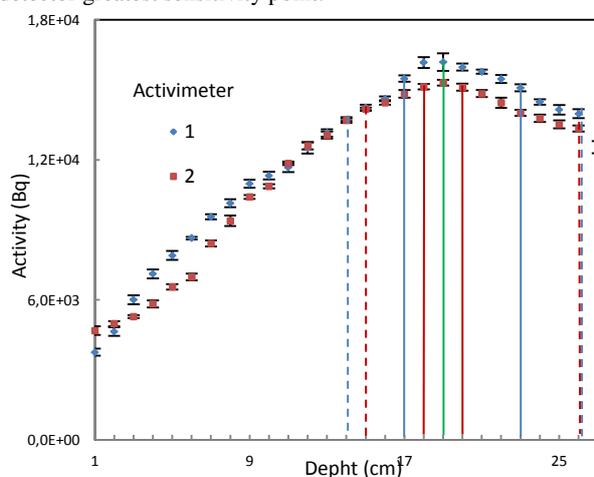
4. RESULTS

The leveling docking showed an uncertainty of 0.07 mm/m. The sliding rod movement in both, longitudinal and the transverse axis, showed ease operation and precision in the indicative degree view, with an uncertainty of 0.01 mm. The sample had a nominal volume of 0.35 microliters [10] and the initial activity of $1{,}5E6 \pm 114.3$ Bq.

The accuracy results before use of the device was 2.62 ± 0.097 and $2.59 \pm 0.144\%$, and accuracy of $0.23\% \pm 0.19$ and $0.31 \pm 0.18\%$, respectively, for detectors 1 and 2.

Was determined the greatest sensitivity range in both detectors and set the optimum dept (O_d) as the point of maximum sensitivity for both detectors (grafic 1).

Graffic 1: The space between the blue and red lines show the source range variation around the conventional true value (ctv). The dotted lines represent the upper and lower limits equivalent to 10% of the VVC. The green line represents the detector greatest sensitivity point.

The activity result was called equivalent depth (E_d), a function of the activity in relation to depth, allowing minimum and maximum depth limits (L_d) determination (1).

$$L_d = E_d \pm 10\,\% \qquad (1)$$

where E_d is the equivalence depth point, L_d is the maximum and minimun limits based on the measurement result (graffic 1). After determined L_d it is possible to determine the correction factors by deph and uncertainties (table 1).

Table 1: The uncertainty estimation considered uncertainty Type A as obtained by statistical calculationand Type B all of others, as manufacturer information.

Uncertainty (%)	N	Activimeter			
		1		2	
		A	B	A	B
Accuracy	10	0.097		0.114	
Precision			0.019		0.018
Rod resolution			0.003		0.003
Background			0.001		0.001
Volume			0.020		0.020
Bubble level			0.001		0.001
csu =		0.1009		0.1172	
U =		0.2276		0.2677	
k =		2		2	

5. CONCLUSIONS

The point of greatest sensitivity in both detectors was determined with reproducibility of 96% and 97%, respectively, for 1 and activimeters. A linear decrease of the measured values towards the detector recess, may be the key to determine correction factors.

The information obtained in the device test has knowledge of the spatial dependence of IC used as activimeters, allowing to provide correction factors for different geometries and evaluation of associated uncertainties to the measurement process of greatness activity.

The results showed that the insertion of input variables, such as radioactive source decay

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and volume gradient must be studied to determine the associated uncertainty.

The device reached its goal, as a low-cost design, good portability and precise results for determining the greater sensitivity point in activimeters enabling the estimate of the associated uncertainty.

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