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DETERMINATION OF GEOMETRY CORRECTION FACTORS TO DIFFERENT VIALS USED TO RADIOPHARMACEUTICAL ACTIVITY MEASUREMENTS

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ABSTRACT

The aim of this study is to present the geometry correction factors and their respective uncertainties to P6 and 10R vials and 3 mL and 5 mL plastic syringes using the reference activity meters present at the Laboratório de Calibração de Instrumentos (LCI), IPEN the secondary standard system Capintec NPL-CRC radionuclide calibrator, with traceability to the National Physics Laboratory (NPL), England and the work standard Capintec CRC-15BT and the Capintec CRC-25R. The procedure was made using ^{99m}Tc, which is responsible for about 80 % of the routine procedures in a nuclear medicine service. Variations of up to 40 % between different vials using the same radionuclide were found.

1. INTRODUCTION

The Nuclear Medicine Services must use in their routine procedures at least one radionuclide dose calibrator, also known by activimeter to measure the activity of solutions to be delivered to patients for purposes of diagnosis and therapy.Consequently, an activimeter in perfect operation is required, otherwise may result in inappropriate dose to patients without any benefit. So beyond the regular operational tests, the activimeters must be calibrated by an authorized calibration laboratory and the vials geometry must be considered in this calibration [1].

Ideally, the activimeter calibration must be performed by one calibration laboratory using reference sources traceable to a primary standard, before its first use.After the installation,the itis necessary to perform acceptance tests to verify that the equipment complies with the technical specifications established by the international recommendations [2].Routinely it must be applied quality control tests to ensure the reliability of the activities measurements.

A variety of factors can influence the accuracy on activimeter measurements. The largest sources of error, are related to the types of containers such as the thickness, size and volume that contain these radiopharmaceuticals. Previous studies showed errors of up to 7% due to glass vials geometry [3].

The activimeter should be calibrated for those radionuclides used clinically. However, in Brazil there are no requirement of the activimeter calibration, so studies show that some equipment operating in Brazil are poorly calibrated or have very long intervals of time between calibrations, leading to erroneous values of activity measurements [4].

The radiopharmaceuticals delivered by IPEN to nuclear medicine services are initially the in a P6 type vial and then this material is fractionated into syringes and administered into patients (in vivo). Once the vial and the syringe have different geometries changes in distribution and volume of the material happen. This can affect the calibration factors for each container.

The purpose of this study is to determine these correction factors for glass vials types P6 and 10R and plastic syringes with 3 and 5 ml both with different shapes. The publication NM-3.05 from Brazilian Nuclear Commission recommends that the geometry test must be done annually [5]. It was used the radionuclide ^{99m}Tc because it is used in about 80% of the nuclear medicine procedures [6].

2. MATERIALS AND METHODS

The measurements were performed using three different activimeters : the Secondary Standard NPL-CRC radionuclide calibrator manufactured by Capintec, traceable to National Physical Laboratory (NPL) England and two work standards, one Capintec CRC-15 BT and one Capintec CRC-25R (Fig.1)

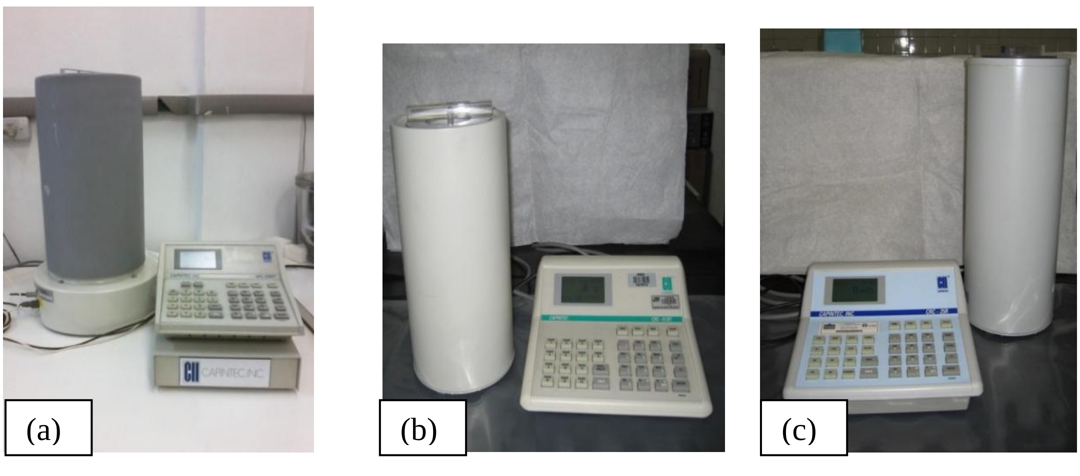

Figure 1: Activimeters used to measure the different vials:

a. **Calibration Laboratory reference secondary standard activimeter , Capintec NPL-CRC**
b. **Work standard activimeter Capintec, model CRC-15 BT**
c. **Work standard Capintec, model CRC-25R**

The containers tested were two glass vials, P6 and 10R models (Fig.2) and two BD syringes, with 3 ml and 5 ml volume from brand (Fig.3). It was measured the activitie of ^{99m}Tc radionuclide samples , provided by the radiopharmacy center of IPEN.To handling the samples of 3 mL each (1 mL of ^{99m}Tc and 2 mL of saline)were used some accessories such as aprons, gloves and tweezers. Table 1 and 2 show the main characteristics of the vials and syringes used.

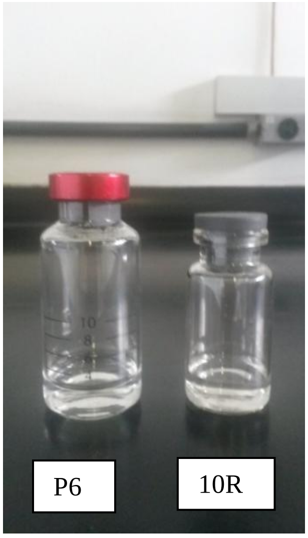

Table 1: Mains characteristic of the glass vials used

Vials Type:	P6 (reference)	10R
Height (mm)	57.7	45.0 ± 0.5
Diameter (mm)	26.5	24.0 ± 0.2
Wall Thickness (mm)	1.2	1.00 ± 0.04
Volume (mL)	22.9	13.5

Figure 2:Glass vials used to measure the ^{99m}Tc samples

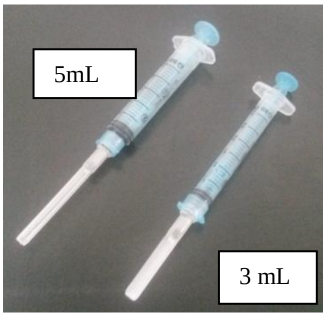

Table 2: Mains characteristics of the syringes used

Syringes	3mL	5mL
Height (mm)	65.0	68.95
Diameter (mm)	13.6	10.1
Wall Thickness (mm)	1.0	0.9
Volume (ml)	3.0	5.0

Figure 3:Syringes used to measure the ^{99m}Tc samples

The methodology applied was divided in 4 steps. In all case the initial measurements were done with the secondary standard reference activimeter NPL-CRC, following by the two work standards. The decay calculation was applied to the correction factors determination considering the technetium (Tc) half-life of 6.01 hours.

Step 1: The four containers (P6 and 10R vials and the 3 and 5 mL syringes) were field with 3 mL of ^{99m}Tc and the measurements were done to the three activimeters.The correction factors were obtained for each container for each activimeter separately by the ratio between the corrected activity measured by the NPL-CRC and the reading obtained by the other two activimeters.

Step 2: Using the vial P6 as reference, the 3 mL sample was measured in it. After that, the same sample was transferred to the 10R vial, and the 3 and 5 mL syringe, successively. The correction factors were obtained for the 10R vial and the syringes using the same calculation.

Step3: Using the P6 vial (used by NPL, English Primary Standard Laboratory) as reference to calibrate the syringes of 3 and 5 mL. The same sample was used in all containers.

Step 4: Using the 10R vial (sent to the Nuclear Medicine Services by IPEN) as reference to calibrate the syringes of 3 and 5 mL.The same sample was used in all containers.

All correction factors were obtained by the ratio between the activity measured with the secondary standard activimeter and the measured with the other activimeters. The uncertainties were calculated using the type A and B contribution.

3. RESULTS

The correction factors to the each container considering the NPL-CRC as reference are shown in Tab.3 . These factors correspond to the calibration of the two activimeters. It is possible to see that using different vials to calibrate an activimeter, the difference found was 2.4 % to CRC-15BT and 1.6 to CRC-25R.

Table 3: Correction factors for the two activimeters using different vials ant the NPL-CRC as reference

	Correction factors	
NPL-CRC (Reference)	CRC-25R	CRC-15BT
Vials P6	1.025 ± 0.079	1.045 ± 0.079
Vials 10 R	1.021 ± 0.067	1.041 ± 0.067
Syringes 3 ml	1.011 ± 0.068	1.023 ± 0.068
Syringes 5 ml	1.009 ± 0.111	1.021 ± 0.111

The results obtained when the same sample was measured with different container using the P6 vial as reference are in Table 4. The syringe of 5mL shows the bad response, higher than 10% of variation to NPL-CRC activimeter. The 10R vial shows the smaller factors

Table 4: Correction factors for different containers using the P6 vial as reference

NPL-CRC (Reference)	**Vials P6**	**10 R**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.013 ± 0.103	1.096 ± 0.105	1.109± 0.136
CRC-25R	**Vials P6**	**10 R**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.009 ± 0.006	1.082 ± 0.007	1.092 ± 0.007
CRC-15BT	**Vials P6**	**10 R**	**Syringes 3 ml**	**Syringes 5 ml**
Correction factors	→	1.009± 0.006	1.073 ± 0.007	1.084 ± 0.006

To calibrate the syringes it was used the P6 vial as reference, considering that this vial is the one used to calibrate the NPL-CRC by the Primary Laboratory. The obtained factors are in Table 5, It is possible to notice that in this case the worse result was found to 3 mL syringe (7,1%). It is important to notify that the syringes used in the three steps are not the same.

Table 5: Correction factors for the syringes using the P6 vial as reference

NPL-CRC (Reference)	**VialsP6**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.071 ± 0.006	1.007 ± 0.006
CRC-25R	**Vials P6**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.059 ± 0.004	1.019 ± 0.005
CRC-15BT	**Vials P6**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.061 ± 0.003	1.021 ± 0.004

Considering that the Nuclear Medicine Service receives the radiopharmaceuticals from IPEN in a 10R vial, it was analyzed the calibration of the syringes using this vial as reference. The correction factors are in Table 6. It is possible to realize huge factors, up to 40%. This is the worse situation but is the one presented in a clinical procedure.

Table 6: Correction factors for the syringes using the 10R vial as reference

NPL-CRC (Reference)	**10 R**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.36 ± 0.005	1.4 ± 0.005
CRC-25R	**10 R**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.342 ± 0.005	1.381 ± 0.005
CRC-15BT	**10 R**	**Syringes3 ml**	**Syringes5 ml**
Correction factors	→	1.327 ± 0.005	1.366 ± 0.005

3. CONCLUSIONS

The correction factors found in all situation show the need of apply correction to activity measurement not only for the activimeter but to different container, including the syringes. The worse results found when it was used the 10R vial as reference to calibrate the syringes, suggest that the Nuclear Medicine Service must calibrate the syringes too before use. It was possible to realize that different syringes with the same volume may possibly show different correction factors.

The Calibration Laboratory of IPEN is developing a method to calibrate the activimeters that will consider the vial or the syringe geometry in the correction factor. In this study it will used two activimeter belonging to the IPEN. The continuation of this study will include clinical activimeters.

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