# Determination of the influence factors of the radiopharmaceutical vials dimensions used for activimeter calibration at IPEN

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## Abstract

This paper presents the establishment of a quality control programme and the correction factors for the geometry of the vials used for distribution of radiopharmaceutical and activimeters calibration, considering that the Calibration Laboratory of Instrumentos (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN) has a NPL-CRC Secondary Standard Radionuclide Calibrator System, manufactured for the Southern Scientific plc, compound by an ionization chamber well type and a current measurement system, with traceability to National Physical Laboratory (NPL) and calibrated with a P6 vial type with different dimensions of the one used for the IPEN. The radiopharmaceutical produced by IPEN $^{67}Ga$, $^{131}I$, $^{201}Tl$ and $^{99m}Tc$, had been tested using the two different vials. The results shown a maximum variation of 22% for $^{201}Tl$, and the minimum variation was 2.98% for $^{131}I$. The correction factors must be incorporated in the routine calibration of the activimeters.

## 1. Introduction

The efficiency and safety of the nuclear medicine practice depend, among others factors, of a quality control programme, mainly related to the use of the nuclide activity meters (activimeter)[1,2,3]. One of the most important sources of errors in the activimeter measurements is the thickness, size and volume of the vial that contains the radiopharmaceutical considering that a typical activimeter has its response dependent of the vial used[4]. The objective of this work was to establish a quality control programme and the correction factors for the geometry of the vials used for distribution of radiopharmaceutical and activimeters calibration, considering that the Calibration Laboratory of Instrumentos (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN) has a NPL-CRC Secondary Standard Radionuclide Calibrator System, manufactured for the Southern Scientific plc, compound by an ionization chamber well type and a current measurement system, with traceability to National Physical Laboratory (NPL) and calibrated with a P6 vial type with different dimensions of the one used for the IPEN. This instrument is used to calibrate the activimeters used by the IPEN radiopharmaceutical production department as well as the ones used by some nuclear medicine services in São Paulo[5,6].

Until the year 2000 the National Physical Laboratory used the P6 vials type to calibrate the Secondary Standards Activimeters. After that, this type of vial was replaced by the 10R type, with different dimensions. Studies show a difference of 10% using these 2 vials making the NPL to determine correction factors to its mainly reference instruments to calibration and recommended that all traceable laboratories shall apply those corrections[7]. However, the vial used by the IPEN radiopharmaceutical production department has different dimensions of the P6 and 10R vials and the correction factors presented by the NPL can not be directly applied.

## 2. Materials and Methods

### Intercomparison activimeters

To evaluate the activimeter response variations it was used two instruments: the NPL-CRC® secondary standard reference system (traceability to NPL) and a commercial Capintec basic CRC®-15BT, they can be seen at FIG. 1.

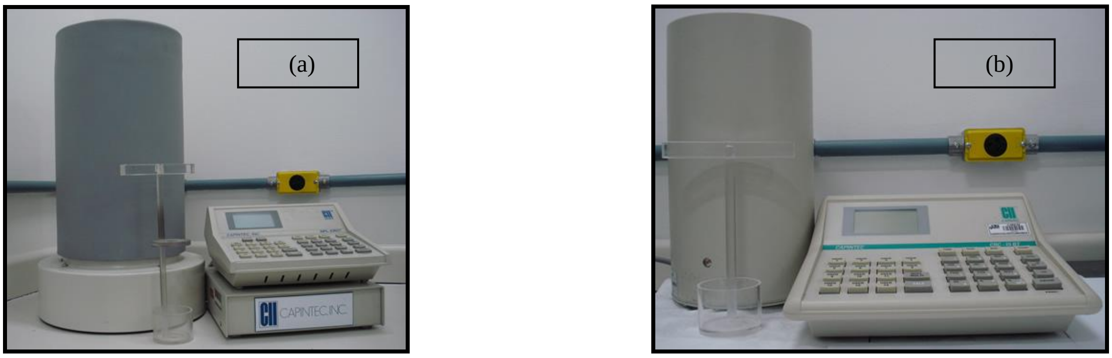


**Figure 1:** (a) NPL-CRC® secondary standard reference system
(b) Commercial Capintec basic CRC®-15BT

**Vials characterization**

The vials used in this study are shown in FIG. 2. Their dimensions are presented in Table 1. To make easier the identification they are here called as IPEN vial and NPL P6 vial.

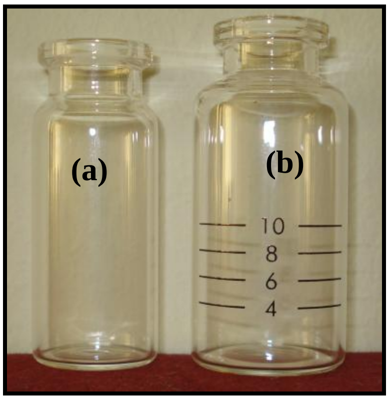


**Figure 2:**: (a) NPL-P6 vial  (b) IPEN vial

**Table 1:** Dimensions of the vials used to the geometry test.

| Vial Type | IPEN | NPL-P6 |
|---|---|---|
| Height (mm) | 57.80 ± 0.05 | 54.00 ± 0.75 |
| Diameter (mm) | 26.5 ± 0.05 | 21.75 ± 0.25 |
| Wall thickness | 1.50 ± 0,05 | 1.2 ± 0.1 |
| Maximum volume (ml) | 22.9 | 13.8 |

**Correction factor and uncertainties determination**

The vial geometry correction factors were obtained by the equation 1:

$$\text{Correction factor} = \frac{\overline{A}_s}{\overline{A}_{fp}} \qquad (1)$$

Where: $\overline{A}_s$ = NPL-P6 vial average activity measurement

$\overline{A}_{fp}$ =IPEN vial average activity measurement

To the uncertainties estimation it was used the norm ISO GUM [8] and it was considered the type A and B uncertainties to a confidence level of 95% (k=2). The correction factors uncertainties were calculated from the uncertainties propagation in correlated variable as indicated in equation 2 [9]:

$$\frac{\sigma_{FC}}{FC} = \sqrt{\left(\frac{\sigma_{\overline{A}s}}{\overline{A}_s}\right)^2 + \left(\frac{\sigma_{\overline{A}f}}{\overline{A}_p}\right)^2 - 2\frac{\operatorname{cov}(\overline{A}_s, \overline{A}_{fp})}{\overline{A}_s . \overline{A}_f}} \qquad (2)$$

## 3. Results

For the radionuclides supplied by the radiopharmaceutical production department it was used samples with the same volume (4ml) and the activities were determined using the secondary standard activimeter. The Table 2 shows the main characteristics of the samples and the activities obtained for each one.

**Table 2**: Main characteristics of the radionuclides used in this work.

| Radionuclide | Photon main energy (keV) | Activity(MBq) | | Half life $T_{1/2}$ | Uncertainty |
|---|---|---|---|---|---|
| | | IPEN vial | NPL-P6 | | |
| $^{67}Ga$ | 93 | 164.2 | 154.0 | 3.26154 $\pm$ 0.00054 d | 0.00015 |
| $^{131}I$ | 364 | 74.2 | 76.9 | 8.0197 $\pm$ 0.0022 d | 0.0005 |
| $^{201}Tl$ | 69, 83, 135 | 163.5 | 209.0 | 3.0456 $\pm$ 0.0015 d | 0.0004 |
| $^{99m}Tc$ | 140 | 1245.7 | 1173.7 | 6.00718 $\pm$ 0.00087 d | 0.00015 |

All radionuclides were homogeneously diluted in 4ml of saline solution and 10 consecutively measurements with 30 seconds between them were done. The measurements were made with the both activimeters and correction factors considering the NPL-P6 vial as reference were obtained. The table 3 shows the correction factors obtained for $^{67}Ga$, $^{131}I$, $^{201}Tl$ and $^{99m}Tc$.

**Table 3:** Geometry correction factors obtained using the NPL-CRC and the CRC-15BT activimeter. Sample volume: 4 ml.

| **Radiopharmaceuticals** | **Correction factors** | |
|---|---|---|
| | **NPL-CRC®** | **CRC®-15 BT** |
| Gallium - 67 | 0.938 $\pm$ 0.001 | 0.940 $\pm$ 0.005 |
| Iodine - 131 | 1.037 $\pm$ 0.001 | 1.031 $\pm$ 0.002 |
| Thallium - 201 | 1.279 $\pm$ 0.001 | 1.288 $\pm$ 0.002 |
| Technetium – 99m | 0.942 $\pm$ 0.001 | 0.942 $\pm$ 0.001 |

## 4. Conclusions

The obtained difference between the responses of the two activimeters used in this study shows the necessity of this kind of instrument calibration, even the national law does not recommending the calibration but only the application of a quality control programme. In addition the geometry correction factors must be considered in the activimeters calibration because they can change the calibration factor in almost 30% (to $^{201}Tl$, for exemplo).

Considering the variation in the obtained correction factors (from 0.938 to 1.288) due to vial geometry, it is important to establish a procedure to determine the correction factor to all radiopharmaceuticals produced by IPEN. A new study must be done if the vial supplier changes its dimensions.

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