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Activimeter Calibration Application for ^{131}I

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1. Introduction

In the nuclear medicine services (NMS), radioactive materials are widely used, both for diagnosis and therapy, and their activities must be accurately determined before administration to a patient to obtain desirable treatment results. To ensure the reliability of the dose prescribed by the doctor, a measuring instrument called an activimeter, previously called a curiometer, is used. The National Nuclear Energy Commission establishes that in the SMN we have at least one activity meter and that periodic tests are carried out as part of a quality control program. These activity meters must be well calibrated so that they provide the most reliable results possible, and the finding factors must be traceable to each radionuclide. IPEN's Instrument Calibration Laboratory (LCI) provides calibration services for radiation measuring instruments for hospitals, industries and clinics located throughout Brazil. It is also responsible for the quality control of all activity meters used at the IPEN Radiopharmacy Production Center (CERAF). In SMN, activimeters are usually installed in controlled areas, with difficult access and difficult transport, corroborating an impasse in their experience. With this in mind, LCI has been developing reliable "in situ" methodologies where only the radionuclide is transported and not the activimeter [1]

2. Methodology

Since the development of the new methodology and the execution of the present study, all steps for calibrating the activity meters had as reference the methodology applied in the National Primary Physical Standardization (NPL) [2], England. The reference activity meter used was the secondary standard belonging to the LCI model CRC-25R series 252669, which has NPL traceability and is shown in Fig. 1.

Figure 1: Reference activimeter - LCI

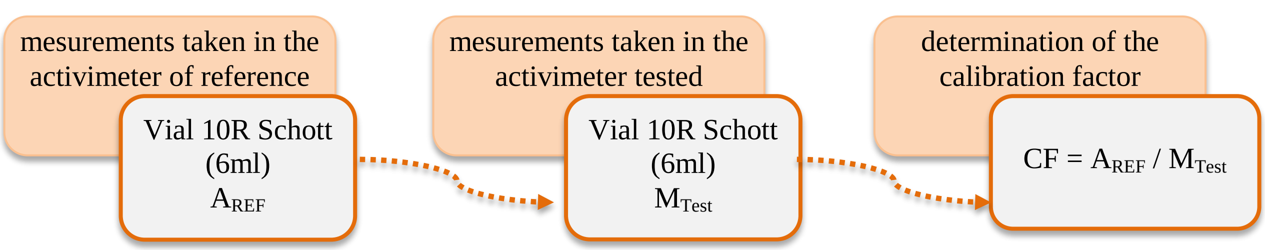
Eleven activimeters were used, Table 1, belonging to IPEN's radiopharmacy production center, and they were tested using the radionuclide ^{131}I dedicated to the treatment of both non-malignant disorders and thyroid cancer.

Table I: Activimeters used in this study - CERAF.

Activimeter	Model	Serie nr.
1	CRC-15 BT	510191
2	CRC-25 R	252537
3	CRC-15 R	157874
4	CRC-15 R	157173
5	CRC-15 R	157816
6	CRC-15 R	158945
7	CRC-15 R	158944
8	CRC-15 R	154896
9	CRC-15 R	155183
10	CRC-35 R	350181
11	CRC-35 R	350373

To apply the occurrence methodology, the 10R Schott reference vial was used to store the samples that were produced by CERAF, diluted and with a volume of 6ml each. The corresponding samples were made by an authorized CERAF technician. In each activimeter were taken 10 consecutive measurements, with 30 seconds interval between them. Installation factors were corrected for each activimeter. The tests were carried out respecting identified measurement conditions. The diagram below shows every step of the methodology applied.

Diagram: Determination of calibration factor



The measurements were taken in all activimeters and the calibration factors (CF) were obtained by the ratio between measurements on the reference activimeter (AREF) and the test activimeters (MTest), as shown in

Equation 1 [3].

$$CF = \frac{A_{REF}}{M_{Test}} \qquad (1)$$

The uncertainty calculation was obtained based on the estimates of type A and type B, possibly for a 95% confidence level (k=2). The type A uncertainty was estimated by standard deviation and average deviation standard, type B information were based on a set of variables of each activemeter. The uncertainty of the calibration factor was calculated based on variables of error propagation correlated on Equation 2:

$$\frac{\sigma_{CF}}{CF} = \sqrt{\left(\frac{\sigma_{\bar{A}_{REF}}}{\bar{A}_{REF}}\right)^2 + \left(\frac{\sigma_{\bar{M}_{Test}}}{\bar{M}_{Test}}\right)^2 - 2\,\frac{\mathrm{cov}(\overline{A'}_{REF}, \overline{M'}_{Test})}{\bar{A}_{REF} .* \bar{M}_{Test}}} \qquad (2)$$

Were: $\sigma_{CF} = uncertainty\ of\ calibration\ factor$

$CF = calibration\ factor$

3. Results and Discussion

The calibration factors were obtained using Equation 1 and are reported on Table 2.

Table 2: Calibration factors obtained with radionuclide ^{131}I for the tested activimeters.
Activity of the reference: 0.559 ± 0.027 GBq

Activimeter	**Measured activity in activimeter M_{Test} (GBq)**	**Calibration Factor A_{REF}/M_{Test}**
1	0.552 ± 0.032	1.012 ± 0.038
2	0.559 ± 0.152	1.000 ± 0.013
3	0.550 ± 0.033	1.016 ± 0.069
4	0.567 ± 0.032	0.986 ± 0.047
5	0.588 ± 0.050	0.951 ± 0.013
6	0.553 ± 0.049	1.010 ± 0.037
7	0.559 ± 0.032	0.999 ± 0.071
8	0.560 ± 0.067	0.998 ± 0.069
9	0.552 ± 0.046	1.011 ± 0.097
10	0.559 ± 0.031	1.000 ± 0.068
11	0.560 ± 0.026	0.997 ± 0.049

4. Conclusions

After applying the methodology using specific techniques, the results obtained from the tested activimeters demonstrated their importance given that lack of correction factors can represent an error of up to 5% for ^{131}I.

Acknowledgements

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