ACCEPTANCE TEST OF AN ACTIVITY METER TO BE USED AS REFERENCE IN A CALIBRATION METHODOLOGY ESTABLISHMENT

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ABSTRACT

The nuclear medicine is a medical physics area in which radiopharmaceuticals are used in diagnostic procedures. These radioactive elements are administered in the patient and the radiation emitted is detected by an equipment, that makes the body scan, connected to a computer software, and the image is constructed. In order to operate the nuclear medicine service must have calibrated radiation detectors. Thought, it doesn't exist, in Brazil, an activity meter calibration methodology, which causes many measurement uncertainties. The goal of this study is to present the acceptance test results of an activity meter to be used as reference in a new calibration methodology establishment. It was checked an activity meter Capintec, CRC-25R model, using three control sources (137Cs, 57Co, 133Ba). The tests were based on the CNEN-NN 3.05 standard, the manufacturer manual, the TRS-454 and the TECDOC 602 and include: physical inspection, chamber voltage, zero adjustment, background response, data check and repeatability. The linearity and geometry tests could not be made, because the laboratory where the activity meter is located is not authorized to receive non-sealed radioactive sources. The equipment has presented a good behavior. All the results are in the range presented by national and international standards and the equipment is now being used in the laboratory and periodically passes through the quality control tests.

1. INTRODUCTION

The nuclear medicine is a medical physics area that employs radioisotopes in the diagnosis and treatment of diseases [1]. The radioisotope applications in nuclear medicine are many, and in this case they are normally used to analyze the physiology of the tissue to be studied [2].

These radioactive elements are administered in the patient and the radiation emitted is detected by an equipment, that makes the body scan, connected to a computer software, and the image is constructed.

In Brazil, in order to operate, the nuclear medicine service must be authorized by the Agência Nacional de Vigilância Sanitária (ANVISA) and the Comissão Nacional de Energia Nuclear (CNEN), which require for all the necessary documentation such as area and surface monitors calibration certificates, contract with a radiation protection supervisor etc [3,4,5].

The activity meter is one of the essential instruments to be held by a nuclear medicine service[5]. It is mainly used to verify if the activity of a given radiopharmaceutical is adequate to be administrated to the patient.

Despite its importance in a nuclear medicine service, the activity meter calibration is not requested by the Brazilian authorities, and there is no national laboratory that provides this service.

The Instruments Calibration Laboratory (LCI) at the Instituto de Pesquisas Energéticas e Nucleares (IPEN) has the diagnostic radiology calibration qualities established on its X-ray system[6,7,8], and now a activity meters calibration laboratory is being setting up.

The aim of this study is to present the results obtained during the acceptance test of a new activity meter acquired by LCI to be used as reference in the calibration methodology establishment.

2. MATERIALS AND METHODS

2.1. Materials

The acceptance test was made in an activity meter Capintec, CRC-25R model (figure 1), using three control sources (^{137}Cs, ^{57}Co, ^{133}Ba, see figure 2).

Figure 1. Activity meter Capintec, CRC-25R model

Figure 2. From left to right: ^{57}Co, ^{137}Cs and ^{133}Ba sources to the quality control tests

In the table 1 are presented the main characteristics of these radioisotope.

Table 1. Main characteristics of the radioisotope used in the acceptance test

Radioisotope	Main photon energy (kev)	Half-life	Nominal Activity (μCi)	Reference date
^{137}Cs	662	30.0 y	196.3	01 Nov 2009
^{57}Co	122	271 d	5590	01 March 2010
^{133}Ba	81, 356	10.7 y	258.1	01 Nov 2009

2.2. Methods

The testes were based on the CNEN-NN 3.05 standard [5], the TRS-454 [9], the TECDOC-602 [10] and the manufacturer manual. Some tests have been called as the automatic tests, because these tests are made automatically by the instrument when option “Daily Test” is chosen.

2.2.1. Physical Inspection

The purpose of this test is to verify the activity meter general conditions. It consists of inspecting the instrument housing for evidence of damage, including its controls, plug-in modules, push-buttons, switches, connectors and accessories [10].

This procedure must be carried out immediately on receipt of the instrument, and the supplier must be informed of any damage or deficiencies [10].

2.2.2. Chamber Voltage (Automatic Test)

This test is made to verify if the chamber voltage is constant and in accordance with the value presented by the manufacturer manual. It is made automatically by the activity meter, and the message “OK” is shown if everything is correct.

2.2.3. Background Response (Automatic Test)

According to the TRS-454, the objective of the background (BG) ongoing monitoring “*is used as an indicator that the electronic noise is not deteriorating and that unexpected sources of radiation are not presented*”[9].

To made this test all the radioactive sources must be removed from the activity meter immediate vicinity. The result is then recorded together with the model and serial number of the activity meter, and the date of the test. If an adjustable zero control is provided, the equipment must be adjusted for zero reading [9, 10].

2.2.4. Auto Zero (Automatic Test)

In some activity meters the zero adjustment is made automatically, and is part of the daily tests routine. This is the case of the CRC-25R. After measuring the background this instrument makes the zero adjustment, so it is not necessary to subtract it from the measurements. If this procedure is made correctly an “OK” is shown at the display.

2.2.5. Data Check (Automatic Test)

In this test the activity meter makes a verification of all the information about the sources inserted in its database. After the check, if everything is right, the message “OK” is shown on its display.

2.2.6. Measurement Accuracy

Measurement accuracy is the “closeness of agreement between a measured quantity value and a true quantity value of a measurand” [11]. To obtain the accuracy the activities measured in the activity meter were compared with the nominal activity, corrected for the source decay. The accuracy D is obtained according to the equation 1:

$$D = \frac{(1-A_i)}{A_v} \text{x } 100 \ \% \tag{1}$$

where A_i is an individual measurement and A_v is the conventional activity value [5].

2.2.7. Measurement Precision

Measurement precision is the “closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions”[11], and the it must be made using . The precision P is obtained according to the equation 2:

$$P = \frac{(A_i - A)}{A} \text{x } 100\ \% \qquad (2)$$

where A_i is an individual measurement and A is the mean of the activities measured [5].

For the measurement accuracy and precision all the information about the radioisotopes (type, nominal activity and reference date) were inserted into the activity meter memory.

3. RESULTS AND DISCUSSION

Following are the results obtained during the tests. The automatic tests (chamber voltage, background response, auto zero and data check) were placed together to help the understanding.

3.1. Physical Inspection and Automatic Tests

There was no damage found in the physical inspection. All the plug-in modules, push-buttons, switches and connectors were working properly.

During the first "Daily test" procedure the activity meter presented a good behavior, as presented in table 2.

Table 2. Results obtained during the "automatic tests". The display show "OK" when the instrument passes the test

Test	Activity meter status
Auto zero	OK
Background (BG)	OK
Chamber Voltage	OK
Data Check	OK

The activity meter CRC-25R has passed the tests. The instrument measured a background activity of about 0.52 μCi, a value much lower than the quality control reference sources.

3.2. Measurement accuracy and precision

The results for the measurement accuracy are shown in table 3.

Table 3. Results for the measurement accuracy. The variation between the Measured and the nominal activity were within the limits, in all cases.

Radioisotope	Nominal activity (μCi)	Measured activity (μCi)	Variation (%)
^{137}Cs	179.6	185 ± 2	2.92 ± 0.03
^{57}Co	213	209 ± 2	-1.91 ± 0.02
^{133}Ba	200	201 ± 2	0.50 ± 0.01

The result for the measurement precision presented a standard deviation of zero, for both three used radioisotope. This might both indicate that this instrument is very stable, or its display does not have enough resolution to show more decimal digits. This will be verified during the daily tests, which will be made from now on.

4. CONCLUSIONS

The acceptance tests were made on the activity meter Capintec, CRC-25R model, and it presented good results. No damage was found during the physical inspection, and during the chamber voltage, background response, auto zero and the data check tests this instrument showed the message "OK", which indicates that everything was working properly.

The measurement accuracy showed a maximum variation of about 2.92%, which is within the range presented by national and international standards.

The measurement precision presented a standard variation of zero, for both three radioisotope used in these tests. This might indicate that this instrument is very stable, or its display does not have enough resolution to show more decimal digits. A further verification of this behavior, during the daily tests, will be made.

In general this instrument presented very good characteristics and a very stable behavior, and will be used as reference for the establishment of the new activity meters calibration methodology.

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