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PRELIMINARY MEASUREMENTS TO THE ESTABLISHMENT OF A QUALITY CONTROL PROGRAMME FOR THE ACTIVIMETER CALIBRATION REFERENCE SYSTEM

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ABSTRACT

The nuclear medicine techniques efficiency and safety depends on, beside other factors, a quality control programme, mainly regards to the nuclides activimeter utilization. The Calibration Laboratory of IPEN uses as a work standard, a tertiary standard system Capintec, calibrated at the Accredited Dosimetry Calibration Laboratory of the Medical Radiation Research Center – University of Wisconsin. In this work, as preliminary measurements to establish a quality control programme for the activimeter calibration procedures, initially the repeatability and reproducibility (long term stability) tests were performed using a sealed check source of ^{133}Ba. Later on, to complete this quality control programme other check sources (^{137}Cs, ^{57}Co, ^{60}Co) will be used to perform the same tests. A series of 80 experiments of 10 measurements each has been carried out. The reference system showed a good behaviour to the repeatability test, considering the tolerance limits of 5%. The percent deviations of all tested sources in the activity measurements were lower 1% to ^{133}Ba.

1. INTRODUCTION

The nuclear medicine service is a specific medical facility in charge of the administration of radiopharmaceutical to a patient for diagnosing and also for treating diseases. In these kinds of institutions a variety of radionuclide incorporated to a specific chemical composition is utilized. The records radioactivity obtained by the activimeter characteristic curve in function of the time are analyzed allowing to evaluate in vivo the tissue physiology and metabolism.

The radionuclides used to diagnosis and therapy purposes are artificially produced by cyclotron and nuclear reactor, with short half-lives and are not sealed sources, which means that their handling has to be done according to national and international radiation protection recommendations [1,2].

The instrument used to determine the radionuclides activities administered to patient is the activimeter. This instrument is essential to guarantee the measurements efficiency and reliability. It must be always in perfect functioning to check the radiopharmaceutical activity before its administration.
The implementation of an equipment quality control programme is important for ensure the accuracy and consistency of those measurements and helps in maintaining the safety and

efficiency of both diagnostic and therapeutic nuclear medicine procedures that employ unsealed radioactive sources. The implementation of such programmes has been developing frequently following the increasing of the nuclear medicine procedures and the activimeter utilization.

Regarding to quality assurance programmes, until recently, there has been no uniform, international guidance that was available to assist institutions in developing and implementing such programmes in their countries, particularly in the developing world[3]. The International Atomic Energy Agency (IAEA), in consultation with a group of experts in the representative fields of radioactivity measurement in nuclear medicine, has developed a guidance document that will address this need[4].

In this work it were made preliminary tests to establish a quality control programme of the activimeter used as work standard, following the acceptance limits determined by the Brazilian standard CNEN-NE-3.05[1].

2. MATERIALS AND METHODS

In this study it was utilized the work standard of the Calibration Laboratory of the IPEN (LCI), which is a tertiary standard well type ionization chamber (activimeter). This Capintec basic CRC®-15BT standard system consists of one display unit and the well type ionization chamber, series 180020, calibrated at the Accredited Dosimetry Calibration Laboratory of the Medical Radiation Research Center – University of Wisconsin. This laboratory is traceable to the National Institute of Standard and Technology (NIST).

Typically one activimeter consists of one well type ionization chamber, one electrometer for measuring the small ionization currents; one stabilized high voltage supply, a processing electronics and one display device. An external shield protects the staff from the intense radiation and reduces the background effect to low level radiation (Fig. 1).

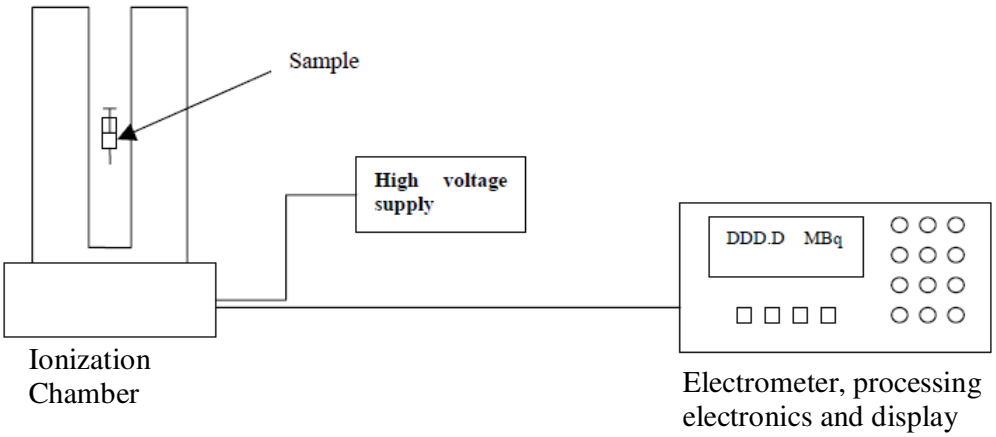

Figure 1- Design of an activimeter system coupled to an electrometer

The radioactive sample is placed into a cavity surrounded by the ionization chamber using its acrylic holder. The passage of ionizing radiation through the sensitive volume of the activimeter ionizes the gas and produces an electrical current; its magnitude is proportional to the activity of the radionuclide being analyzed. The calibration coefficient of the radionuclide is the ratio of the current to the activity. The current generated typically between two electrodes under a constant potential ranges from 10's of femtoamperes (fA) up to microamperes (μA)[5].

In this initial part of the activimeter quality control programme it was used a ^{133}Ba check source, Amersham Buchler GmbH & Co KG*, series number FH-354, calibration traceable to the German Primary Standard Dosimetry Laboratory, Physikalisch-Technische Bundesanstalt, PTB. The active material of the source is homogeneously incorporated in approximately 10 ml resin in a 25 ml plastic vial. The active layer is colour coded nuclide(code BDR562, brown) and is covered by inactive resin. Its drawing can be seen in Fig. 2.

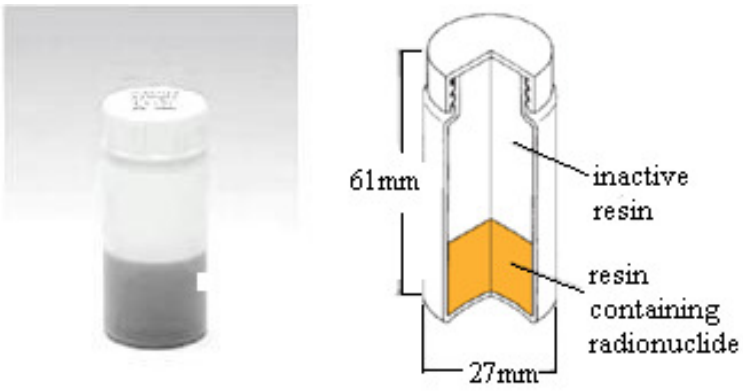

Figure 2 – Dimensions of the ^{133}Ba check source vial.

These preliminary measurements include the repeatability and reproducibility tests. According to International Vocabulary of Metrology (VIM) the repeatability test is defined as a measurement precision under a set of repeatability conditions of measurement and the reproducibility test is the condition of measurement, out of a set of conditions that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects[6]. In this study it was varied the day and time of the measurements. The evaluation was done for 80 set of 10 measurements.

3. RESULTS

To calibrate the reference system for ^{133}Ba check source it was needed to adjust the electronic device using the calibration number 700. This is the calibration number for this source which

* Certificate Amersham n. 249399

will correct its activity to decay. To others nuclides this number will be different. The corrected activity was 3.89 MBq.

After that determination it was made the repeatability test with 10 sequentially measurements with the source into the well cavity. The behaviour and accuracy were verified during the interval of approximately six months. In these preliminary tests, 8 groups (twice a day) of 100 instantaneous measurements each, with 10 seconds between them were made. The total number of measurements was 800. The environmental conditions were monitored during the period of tests. The temperature varied between 18.7 and 21.0°C and the ambient pressure between 92.6 and 92.9 kPa. The air humidity was always about 50%. It was not necessary to correct the measurements because the well type ionization chamber is sealed.
Considering all measurements (since the first value) and using as reference the average of the 10 first measurements, the maximum coefficient variation was 1%. This can be observed in the Figure 3. Each value represents the medium of 10 measurements. Although the obtained variation (1%) is less than the acceptable (5%), it is possible to notice that only after the 30 first measurements the system was totally stabilized.

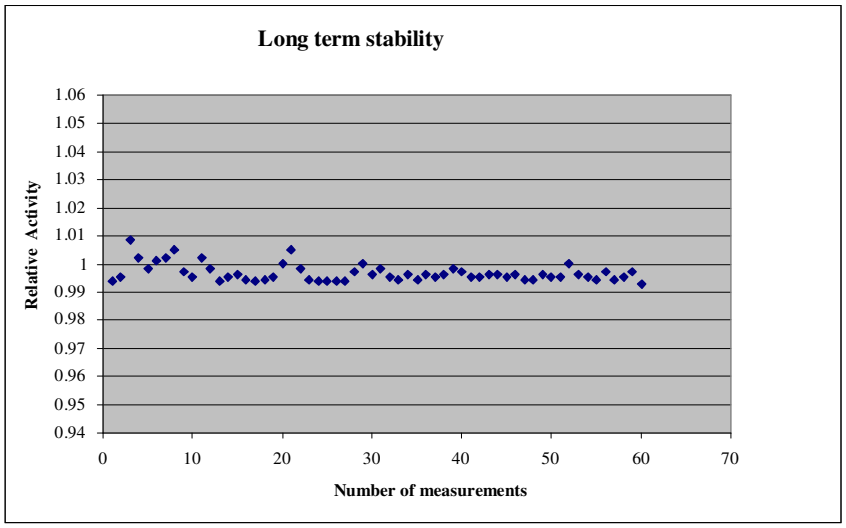

Figure 3 – Long term stability of the reference activimeter

In order to visualize the instrument behaviour after its stabilization a new graph, Figure 4, was made considering only those measurements (after the 30 first measurements). In this case the maximum variation obtained was 0.5%. In all cases the maximum standard deviation found was 0.66%. As this work is the initial part of a complete quality control programme, the uncertainties analysis here considering only the statistical sources as the standard deviation of the mean.

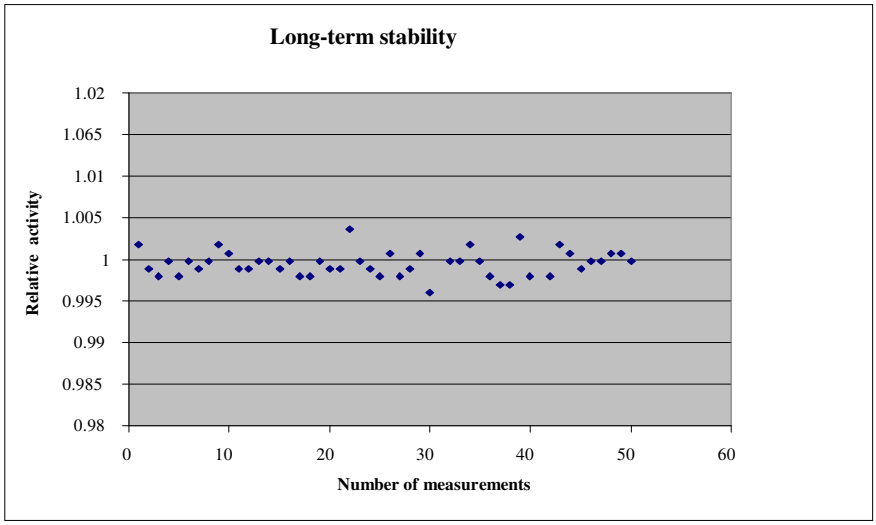

Figure 4 – Long term stability of the reference activimeter, after the total stabilization for the system

4. CONCLUSIONS

The results showed that even after the stabilization time recommended by the manufacturer, the system only presented reliable values after 30 measurements with the check source. The maximum variation obtained was 0.5%. The manufacturer recommends limits to accuracy and constancy of ± 5%. According to the international standard to diagnostic radiology instruments, the repeatability test must be within 3%[7]. The Brazilian standard to nuclear medicine facilities, CNEN-NE-3.05 recommends a limit variation of 5% to constancy and reproducibility tests. Therefore the activimeter tested in this study shows a very good behaviour to the tests applied for this specific source (^{133}Ba). As mentioned before, all tests performed up to now will be applied to the complete set of check sources. The sequence of this study is to analyze the linearity performance to this instrument. The total associated uncertainties must be analyzed considering all sources of errors (calibration, electronics devices, statistical, high and low activity, etc…). Considering that this instrument is not used in nuclear medicine clinics but in a calibration laboratory, the frequencies for those parameters measurements will be determined after the conclusion of the quality control programme following the recommendations of the National Physical Laboratory[5].

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