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STUDY AND SURVEY OF ASSEMBLING PARAMETERS TO A RADIOACTIVE SOURCE PRODUCTION LABORATORY USED TO VERIFY EQUIPMENTS

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ABSTRACT

This paper presents the survey of parameters for the installation and implementation of a laboratory for radioactive sources production at immobilized resin. These sources are used in nuclear medicine for verification of dose calibrators, as the standard guidelines of the National Commission of Nuclear CNEN-NE-3.05 "Radioprotection and safety requirements for nuclear medicine services." The radioisotopes used for this purpose are: Co-57, Cs-137 and Ba-133, with activities of 185 MBq, 9.3MBq and 5.4 MBq, respectively. The parameters for the assembly of the laboratory shall be defined according to guidelines that guide the deployment of radiochemical laboratories and standards of the National Commission of Nuclear Energy.

1. INTRODUCTION

Nuclear medicine is a medical specialty that uses radioactive materials for diagnostic and therapeutic. The radioactive materials are usually administered in vivo and present distribution to certain organs or cell types [1].

To determine the activity of the sources, it is necessary to use a dose calibrator, that usually it is an ionization chamber. The standard guidelines of the National Commission of Nuclear CNEN-NE-3.05 "Radioprotection and safety requirements for nuclear medicine services", at April 1996, determines that all nuclear medicine service must instrumentation examination using references standard sources of Co-57, Cs-137 and Ba-133 Fig.1 with activities of 185 MBq, 9.3 MBq and 5.4 MBq respectively[2,3,4,5].

With the aim of nationalizing the production of radioactive sources, a laboratory is being set up at the Institute of Energy and Nuclear Research - IPEN-CNEN/SP.

Figure 1 - Radioactive solid sources produced IPEN[3]

This work aims are:

- ✓ Parameters study and analysis for setting up a radioactive sources, immobilized in resin, laboratory;
- ✓ Calibration and verification of activity measurement equipment;
- ✓ Survey of radiological protection procedures, connected with a radioactive facility, as well as the environment and the worker.

The radiochemical laboratory design should take into account that the guidelines established in the CNEN standards be considered. Factors such as location, materials to be produced and handled, as well as radiological protection systems should be thought of [6,7,8].

2. METHODS AND MATERIALS

The data collected for disposal of the radiochemical laboratory are based on standards and guides[6,7,8,9,10].

The laboratory handling and storage of sources must have floors and walls with rounded corners and painted with waterproof material. Generally, materials that are used to decontaminate as epoxy or linoleum. The benches should be hard surfaces, resistant to chemicals and sinks shall be stainless steel with plates of aspersion.

The fume hoods must be non-porous material, free from cracks with chemical resistance to gases and smoke of corrosive materials, the speed of air flow to be linear between 0.5 and 1.0 m/s. The minimum level of light for a radiochemical laboratory according to the regulation standard NBR-5413 must be 300 lux.

To control and protect the user of the laboratory is essential the use of coat with long sleeves to protect arms and wrists. The eye protection is important to prevent the entry in the eyes of some radioactive material, shoes and gloves should be sealed lead should be used. Every employee must use a monitoring system be it individually or as Geiger Muller dosimeter for monitoring and surface area.

In the laboratory where it produces radioactive sealed sources, besides the parameters already presented is essential to install a dose calibrator to measure the activity of the sources produced. These calibrators are essentially an ionization chamber of the type well Fig.2 in which the source is introduced for measurement.

The measurement of activity is generated by ionization of the sample with radiation of the gas chamber, usually argon and provided in a display of equipment. This is a device also used in nuclear medicine center it must be in perfect working condition. Some tests are required for verification of the calibrator according to the guidelines of the standard CNEN NE 3.05.

The tests are:

- Testing of Accuracy (Co-57, Ba-133 or C-137) must be made every six months, and allowed percentage deviations of up to 10% with reliability of 90%;
- Precision Test (Co-57, Ba-133 or C-137) must be made every six months, and allowed percentage deviations of up to 5%, with reliability of 95%;
- Test Reproducibility (Co-57 or B-133) must be made annually, while allowing diversion rate of up to 5% with a reliability 95%.

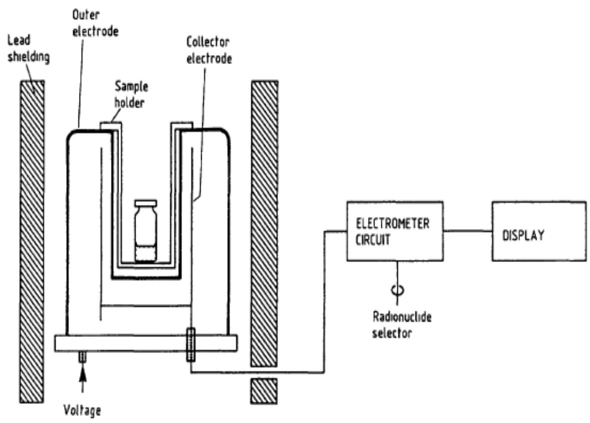

Figure 2 - Outline of the dose calibrator

3. RESULTS

The design of the laboratory production of radioactive sources immobilized in resin was done with the following requirements:

3.1 Floors

The floor will be provided with material impermeable epoxy resin covering its entire length and will not merge.

3.2 Walls

The walls and the floor will be painted with waterproof ink with chemical resistance to make the decontamination easily. This ink will be an epoxy resin to provide high resistance to chemical attack and abrasion.

3.3 Doors

The door of the laboratory meets the requirements of safety and signaling Fig.3. It is provided with latch that opens to both sides, has a vision panel (glass on top) that allows the worker to be observed at all times by those who are outside the laboratory, so that there is a need to enter the site.

Figure 3 - Laboratory door

3.4 Bench

The laboratory bench will be sealed his junction to the wall with silicone to avoid contamination. The bench surface should be smooth, hard, non-absorbent and resistant to chemicals.

3.5 Sink

The sink acquired for the laboratory is stainless steel with rounded front edges, with cards installed in the back aspersion Fig.4. A drainage system will be available for radioactive waste.

Figure 4 - Laboratory sink

3.6 Lighting

The lighting system of the laboratory consists of six lights, three lights in each, generating a lighting of 500 lux in the laboratory.

3.7 Fume Hood

The fume hood of exhaustion was purchased and installed. The fume hood is in stainless steel AISI-304, coated in textured melamine laminate, with-proof luminaire gases and vapors, provided with safety glass and equipped with two standard fluorescent lamps with 500 lux.
Its ventilation system has been certified by the extent of facial speed in meters / second (m/s). Smoke tests were performed Fig.5, in order to verify that the airflow meets the practices recommended by IEST 002.2, followed by the condition responsible for testing. To test the speed and uniformity of air flow is obtained average 0.77 m/s and is to be within the permitted levels.

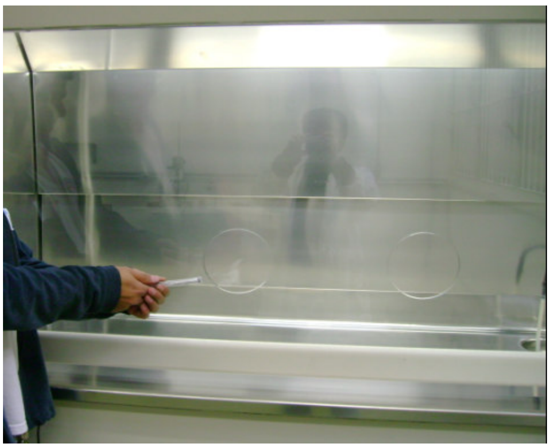

Figure 5 - Smoke test

3.8 Individual Protection Equipment

The individual protection equipments should be purchased according the activity levels, radiation type and materials quantity that will be handling. And at least must be apron, Latex or lead gloves and ear-plugs.
TLD dosimeters will be used for an individual monitoration and Pancake Geiger Muller detectors will be used as area monitors.

3.9 Dose Calibrator

It acquired a brand-dose calibrator Capintec model CRC-15R Fig.6 which is a window with argon gas.

Figure 6 - Dose calibrator CRC-15R

Tests for evaluation of dose calibrators to set the standard CNEN-3.05 were made in the laboratory. Calculations of decay for each source, were performed, so that their activities are fitted to the actual value at the time of testing as follows:

$$\mathbf{A = A_0\, e^{-\lambda t}} \qquad (1)$$

Where:

A= activity final
A_0 = activity initial
λ = constant of decay
t = time

Initially, we conducted a set of 10 measures for each sequential source Co-57, Cs-137 and Barium-133, with an interval of 30 seconds for each measure. The source of Co-57 was provided by the Laboratory of Metrology-LMN -IPEN has certified calibration source. The data are presented in Table 1, for calculation of precision and accuracy were adopted the following formulas:

$$P = \frac{(Ai\text{-}Am)*100}{Am} \qquad (2)$$

Where:

P = precision
Ai = activity measure
Am = average activity

$$E = \frac{(Am\text{-}Av)*100}{Av} \qquad (3)$$

Where:

E = accuracy
Am = average activity
Av = real activity

For calculation of uncertainty using the Student t distribution, the formula is expressed below, then use the table of Student t distribution, to obtain the critical value $t_{\alpha/2}$ of the confidence interval:

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}} \qquad (4)$$

Where:

t = Student's t distribution
x = average
μ = population mean
S = deviation
n = simple size

Table 1 - Measure activity

Radionuclide						
Co-57			**Cs-137**		**Ba-133**	
Activity (µCi)	**324**		**158**		**167**	
Nº Measure	**Measure Activity (µCi)**	**Precision**	**Measure Activity (µCi)**	**Precision**	**Measure Activity (µCi)**	**Precision**
1	342	0,29	162	0,62	166	1,22
2	341	0,00	161	0,00	164	0,00
3	340	0,29	159	1,24	163	0,61
4	341	0,00	161	0,00	164	0,00
5	341	0,00	162	0,62	165	0,61
6	342	0,29	160	0,62	163	0,61
7	339	0,59	162	0,62	164	0,00
8	341	0,00	161	0,00	162	1,22
9	342	0,29	161	0,00	165	0,61
10	340	0,29	162	0,62	163	0,61
Average	341	0,21	161	0,43	164	0,55
Deviation	0,94		0,99		1,20	
Accuracy	5,12		1,90		1,86	
Uncertainty	0,68		0,71		0,86	

4. CONCLUSION

The parameters for fitting the laboratory raised were of great importance in that not only the safety and suitability standards to make it here, but for the worker you're safe in their workplace. The results of tests performed with calibrator CRC-15R dose given the standard CNEN 3:05, as the values of precision and accuracy are within the values established 5% and 10% for precision and accuracy. The Table 1 show the uncertainty within the 5% down, in accordance with student t-value of 95% reliability.

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