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NEUTRON AND GAMMA RADIATION LEVELS ANALYSIS FOR 18 MEV CYCLOTRON OPERATION AT IPEN-CNEN-SP

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ABSTRACT

The Accelerator Cyclotron Facility provides activities that involve exposure to ionizing radiation, so it is necessary to establish a monitoring program that allows the dose control of the workers, based on the principles of the radiation protection. Besides the individual monitoring, the area monitoring is carried out aiming to evaluate the dose rates in areas that are occupied by workers during the execution of their tasks. This study aims to present the levels of neutron and gamma radiation results, obtained by monitoring the Accelerator Cyclotron Facility areas, during the Cyclone-18 operation. The study was based on data gathered from the area monitoring reports conducted by the radioprotection team in the years 2010 and 2011. To determine the dose rate, specific equipment was used. It was monitored 09 spots (from A to I), totalizing 280 and 205 measurements at each spot in the years 2010 and 2011, respectively. The "B" spot showed the least influence for gamma and neutron radiation in both years. The spots with the highest neutron and gamma dose rates, in both years, were the "E" and "I" spots, respectively. With these results, we can say that the area monitoring is carrying out with its goal of preventing the doses that can be accumulated by the workers during the course of their work.

1. INTRODUCTION

An important tool in the diagnosis of diseases is the radiopharmaceuticals, wich are obtained from radioisotopes produced in nuclear reactors or particle accelerators. These radiopharmaceuticals are injected into the patient's body and are concentrated on the area to be examined. Radiation is going to be emitted and it is going to be detected by appropriate equipment, transforming this information into images, allowing the physician to observe the functioning of the studied region.

The Accelerator Cyclotron Facility, located at *Instituto de Pesquisas Energéticas e Nucleares*, IPEN, is a nuclear facility that produces short-lived radioisotopes for diagnostic use in medicine. This facility has two cyclotrons accelerators: the Cyclone-30 that can accelerate protons to energies between 15 and 30 MeV and it is now used for the production of Iodine-123 and Fluorine-18 and the Cyclone-18 which accelerates protons to 18 MeV and is used to produce Fluorine-18.

Being a facility that provides activities that involve exposure to ionizing radiation, it is necessary to establish a monitoring program that allows workers' dose control, based on the principles of the radiation protection [1,2,3].

Besides the individual monitoring, the area monitoring is carried out aiming to evaluate the dose rates in areas that are occupied by workers during the execution of their tasks.

The facility areas are classified according to the risk of exposure and contamination, considering the location where the accelerator and the support areas are, and these areas can be classified as controlled or supervised [4].

This study aims to present the levels of neutron and gamma radiation obtained results by monitoring the Accelerator Cyclotron Facility areas, during the Cyclone-18 operation, when the Fluorine-18 is being produced.

2. METHODOLOGY

The study was based on data gathered from the area monitoring reports conducted by the radioprotection team in the years 2010 and 2011. To determine the dose rate, specific equipment was used. Such as: portable gamma and neutron radiation detectors: Geiger-Müller Brand Automess Model 6150 AD5 with Teletector probe and, Brand Ludlum Model 15, respectively.

Measurements were performed at 09 predetermined spots by the radioprotection team, identified in Figure 1 by the letters A to I (circled in red is the radiation source of the Cyclone-18) and the Table 1 presents a description about them.

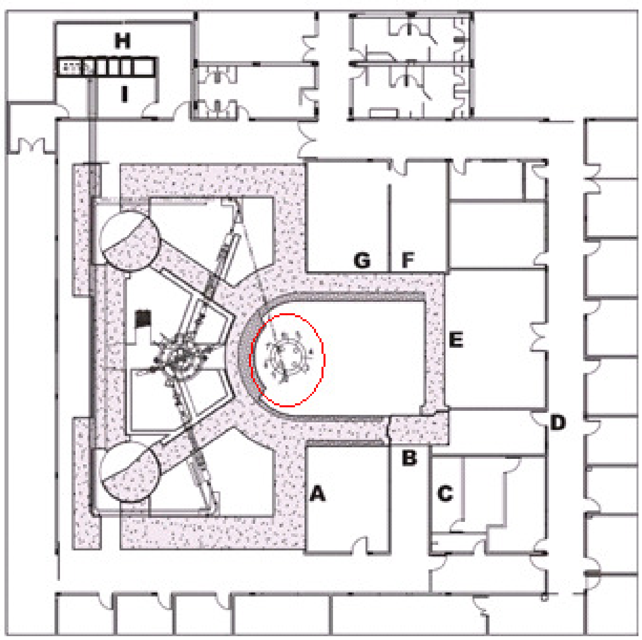

Figure 1: Sketch of the monitored spots

Table 1: Description of the monitored spots in the vicinity of Cyclone-18

Spot	Description
A	Cyclone-18 cave external wall – Radiopharmaceutical production room.
B	Cyclone-18 cave access door.
C	Cyclone-18 control room.
D	Gateway to the facility upper floor.
E	Cyclone-18 cave external wall – Engine room.
F	Cyclone-18 cave external wall – Cyclone-30 control room.
G	
H	Handling laboratory – In front of the hot cells.
I	Hot cell area maintenance – Material exit.

The spots "A" to "G" both gamma and neutron radiation are monitored when the Cyclone-18 is operating, whilst $H_2{}^{18}O$ (enriched water) is being irradiated. In the "H" and "I" spots only gamma radiation is monitored, about 17 minutes after the beginning of the synthesis in the hot cell (evaporation stage beginning).

It was performed 280 and 205 measurements at each spot in the years 2010 and 2011, respectively.

3. RESULTS E DISCUSSION

The results of the monitored spots during the production of Fluorine-18 can be seen in Table 2, which shows the average dose rates for neutron and gamma radiation performed in the years 2010 and 2011.

Table 2: Average dose rates for neutron and gamma radiation for years 2010 and 2011

Year	2010		2011	
Spot	Average dose rates (µSv/h)		Average dose rates (µSv/h)	
	Gamma	Neutron*	Gamma	Neutron*
A	2.71 ± 0.95	11.8 ± 4.3	2.25 ± 0.86	8.0 ± 4.7
B	0.72 ± 0.24	3.6 ± 1.2	0.63 ± 0.16	2.6 ± 1.3
C	0.9 ± 1.3	3.6 ± 1.7	0.75 ± 0.98	2.7 ± 1.5
D	1.11 ± 0.37	6.7 ± 3.3	1.06 ± 0.33	5.0 ± 3.5
E	12.2 ± 2.6	48.8 ± 7.3	12.3 ± 8.0	36 ± 19
F	1.5 ± 2.7	13.5 ± 2.7	1.09 ± 0.84	10.0 ± 5.3
G	1.5 ± 1.3	12.2 ± 2.7	1.36 ± 0.37	9.2 ± 5.2
H	7.4 ± 7.5	-	5.4 ± 6.7	-
I	54 ± 49	-	31.2 ± 19.4	-

* There is no neutron monitoring in the "H" and "I" spots

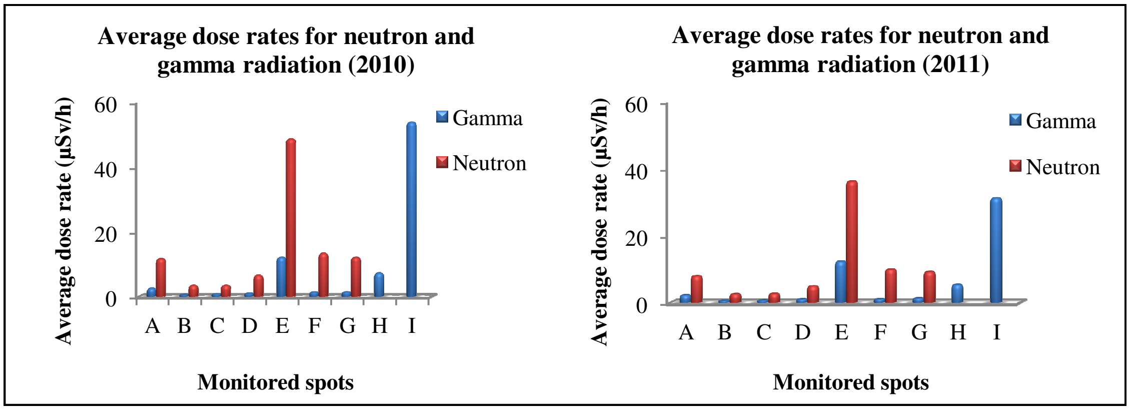

Figure 2: Average dose rates for neutron and gamma radiation

The “B” spot showed the least influence for gamma and neutron radiation in both years, in spite of being positioned near the door of the cyclotron cave.

The reason is due to the direction of the beam not being focused directly on the spot and also because when the cyclotron is in operation, the door is closed. This door was built with a determined thickness, so that the radiation levels outside the cave are not so intense.

The “I” spot showed the highest dose rate for gamma radiation due to the influence of the activimeter located next the spot.

It is observed that "H" and "I" spots showed a large measure of uncertainty. The significant variation between the minimum and the maximum measurements values is due to the number of production carried out over the day, irradiation time, the irradiated material activity and the yield of the synthesis. Therefore the dose rates vary greatly in these two points.

It is noticeable that the spot with the highest neutron dose rate, in both years, was the “E” spot. The radiation beams direction and a thin wall compared to the others spots, make the dose rate higher at this location. This spot, as already showed in Table 1, is inside the engine room, therefore it is not an effective place for people to remain. (occupation factor ¼ [5]).

4. CONCLUSIONS

In the studied period, it was observed that the measurements showed almost constant values at all spots. The reason for this tendency is due to the intensity of the current remaining practically the same and the use of the same stripper most part of the time when measurements were carried out.

With the obtained results, we can say that the area monitoring is fulfilling its purpose, which is to know the dose levels in the workplace, and then to be able to prevent the doses that can be accumulated by the workers during the development of their tasks.

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