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RADIATION MONITORING EXPERIMENT USING THERMOLUMINESCENT DOSIMETER FOR THE TR 19 CYCLOTRON AREA IN NUCLEAR RESEARCH INSTITUTE

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Abstract. The core of Radiopharmaceuticals Research Centre, CCR, is represented by a TR19 cyclotron (Advanced Cyclotron Systems Inc.), a versatile and fully automated and computer controlled machine. This cyclotron accelerates negative ions (H^-), on a vertically arranged plane, up to 19 MeV energy, and is provided with two external beam lines and dual extraction capabilities. The main use is for the production of positron emitting radionuclide namely ^{18}F, ^{15}O, ^{13}N and ^{11}C. The pharmaceuticals labeled with these radioisotopes are used for positron emission tomography (PET) imaging. The radiation levels were measured in the facility at different locations namely cyclotron vault, control console, radiochemistry laboratory, beam extension room and the stack using a comprehensive computerized monitoring system. The thermoluminescent dosimeter, TLD, LiF: Mg, Cu, P are commonly used for the radiation dose measurements to determine the ambient dose equivalent, which are part of passive systems of environmental radioactivity monitoring. In this work TLD were distributed for a period of 87 days in 12 points of interest according to the map of the cyclotron area and were read out to determine the corresponding activities. All measured values were higher than those obtained in IFIN-HH nuclear research units so, at cyclotron vault point the ambient dose equivalent rate was 56 695 nSv/h.

Key words: radiation measurements, thermoluminescent dosimeter, TR19 cyclotron.

1. INTRODUCTION

In year 2012 IFIN-HH has implemented the investment project CCR (Radiopharmaceuticals Research Centre) dedicated to the study of radiopharmaceuticals, both for medical imaging and targeted therapy, in view of their future implementation in medical practice. The project consists of a more than 1330 m² state-of-the-art center comprising one of the newest generation of cyclotrons (TR19) and a highly specialized radiopharmaceutical facility. The cyclotron has an associated radiochemistry facility that contains chemistry modules

housed in adequately shielded hot cells meant for the synthesis of the pharmaceuticals labeled with these positron emitters [1].

During cyclotron operation, some radioactive nuclides are produced by beam activation of the cyclotron materials and surrounded air molecules. The activity varies from place to place inside the cyclotron room and some radioactivity values could be remarkable in the places outside the cyclotron room, in the working area. Concerning with norms and laws [2, 3] in force the CCR activity requires the monitoring and assessment of the environmental radioactivity level. In this way, the CCR has a comprehensive computerized monitoring system with gamma and neutron detectors that monitories permanently all the areas from the building. Also, annually by a program of monitoring the radiation environment level is reported for Horia Hulubei, National Institute R&D of Physics and Nuclear Engineering that included beside other laboratory with nuclear activity and the CCR location.

The principal aim of occupational protection and safety can be stated as the achievement and maintenance of an acceptably safe and healthy working environment. Therefore the mapping of the produced radioactivity in the cyclotron area is important for radiation protection purposes. Besides centralized radiological monitoring system, a passive system of radioactivity measuring would be necessary.

In this work the radiation activity values of the CCR environment measured with SDTM thermoluminescent (TL) environment dosimetry system are presented.

2. MATERIALS AND METHODS

In order to obtain the radiological mapping of the CCR studied area the thermoluminescent (TL) environment dosimetry system has been used. So, the ambient dose equivalent and its flow values have been assessed. The TLD is classified as passive dosimeter and the power supply is not required during its working period. The TLD system consists of: i) thermoluminescent detectors based on LiF: Mg, Cu, P, GR-200 type A; ii) dosimetric box with minicasete 3–7; iii) ANALYSER RA '94 TL reader. The dosimetric box from PVC (polyvinyl chloride) consists of box and lid and its closing is achieved by screwing. The minicasete from the inside of the dosimetric box are also composed of body and lid and are closing by pressing. Also, the minicasete are made from the same material as the dosimetric box Figure 1. The dosimetry box (model DMT-S) is designed and made in IFIN-HH.

The thermoluminescent (TL) environment dosimetry system allows measurement of doses from 0.01 μSv to 100 mSv in the 30 keV ÷ 3MeV range of

energy. For ambient dose equivalent measurement the TL dosimeters were suspended at one meter of the earth surface in studied area.

The TL detector is based on thermoluminescent phenomenon induced of the ionizing radiation and the luminous radiation is emitted by their heating to the characteristic temperature typical for the each type of detector. The radiation intensity is proportional with integrated doses during the exposure period.

Fig. 1 – Dosimetry box with thermoluminescent detectors.

The ambient dose equivalent values have been performed take into consideration the specifically calibration standards and procedures from dosimetry laboratory [4, 5]. In order to determine the calibration factor the TL dosimeters were calibrated to a Secondary Standard Dosimetry (SSD) in the ambient dose equivalent H*(10) [mSv].

In the study, 12 dosimeters box were placed within 12 locations of interest from CCR for a period of 87 days after which they were read and interpreted Fig. 2. In each dosimeter box were paced 3 minicaset with TL detectors. After monitoring period the TL detectors were subtracted from minicaset with a vacuum tweezers and were read to the ANALYSER RA '94 TL reader. The ambient dose equivalent values were assessed taking into consideration the mean values obtained by the reading of the three TL detectors from each dosimetric box.

In the studied period of three months only three experiments occurred in the Cyclotron vault location totaling an operating period of 40 hours.

3. RESULTS AND DISCUSSIONS

Measurements performed in the 12 locations confirmed the high degree of security for workers. As it seen from the Table 1 the equivalent dose inside and outside of the irradiation area is about 118 mSv for three months of monitoring and ranging from 0.219 to 0.341 mSv for the this period of time. So, the annual equivalent dose in the working area varies in the range 0.876 mSv to 1.023 mSv. These values are below the maximum permissible dose for occupational exposed person that is 20 mSv/year [6]. The values outside of the Cyclotron vault are extremely low. The lowest level measured of 104.67 nSv/h is in the control room area where operators working throughout the experiment activity.

In the Cyclotron vault location namely "hot area" the ambient dose equivalent rate value is 3mSv/h take into consideration only those 40 hours of experimental activity. This value is comparable with other types of cyclotrons considering the same rate of experimental operation in the "hot area" [7]. In the access places the dose does not exceed the background radiation level.

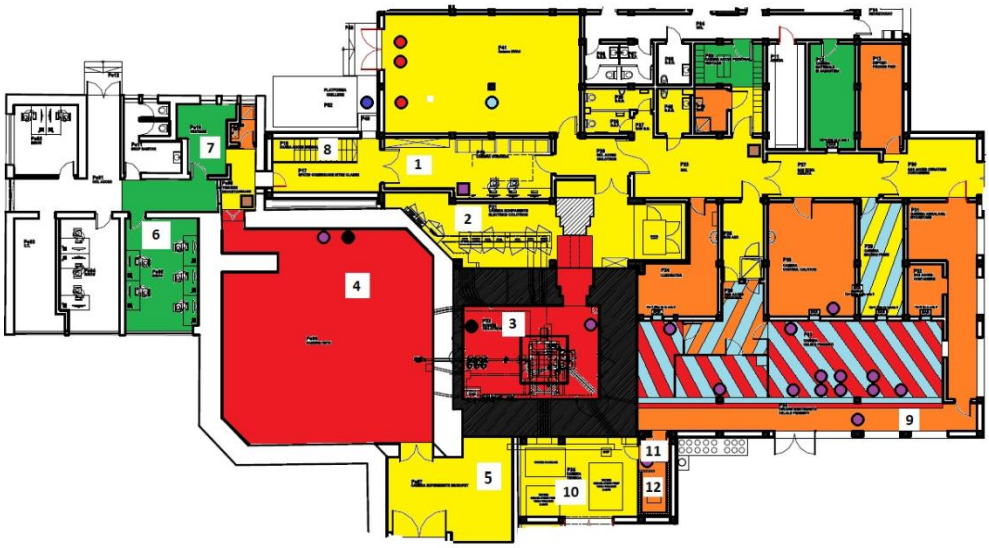

Fig. 2 – Schematic layout of the Radiopharmaceuticals Research Centre and the positions of the monitoring points.

Table 1

Measurement values for ambient dose equivalent and its rate

No	Location	Dosimeter cod	Ambient dose equivalent [mSv]	Ambient dose equivalent rate [nSv/h]
1	Control room	0148	0.219 ± 0.008	104.67 ± 3.99
2	Electrical room	0173	0.341 ± 0.008	163.35 ± 3.91
3	**Cyclotron vault**	0131	**118.379 ± 46.298**	**56 694.80 ±273.26**
4	Experimental Hall	0169	0.334 ± 0.016	159.76 ± 7.43
5	Extension of Experimental Hall	0108	0.290 ± 0.059	138.79 ± 28.40
6	Equipment room	0091	0.285 ± 0.005	136.47 ± 2.16
7	Locker room	0079	0.337 ± 0.035	161.47 ± 16.87
8	Basement	0101	0.278 ± 0.014	133.09 ± 6.62
9	Maintenance corridor	0087	0.307 ± 0.046	147.24 ± 21.84
10	Mechanical room	3003	0.308 ± 0.050	147.35 ± 23.97
11	Room	0186	0.264 ± 0.031	126.21 ± 14.84
12	Potentially radioactive air compressing station	0137	0.275 ± 0.039	131.66 ± 18.51

4. CONCLUSIONS

Using the TL dosimetry system for monitoring the controlled area around the TR-19 cyclotron the ambient equivalent dose and its flow in relevant points inside and outside were recorded. The mean equivalent flow dose recorded:

- In the “hot area” the value of 3 mSv/h is comparable with other types of cyclotrons;
- At the access points for personal the values not exceed the background level. It can be concluded that presently all workers are safe in terms of radiological;
- The comprehensive computerized monitoring system with gamma and neutron detectors that permanently monitories all the CCR area provides an effective solution for the control of various aspects of production and radiation safety in a medical cyclotron facility. In addition the TL dosimetry proved that the radiation levels were observed to be well below the permissible limits.

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