Improving of the Iodine-123 production line shielding on CV-28 Cyclotron

B. L., Cruz[1], C. M., Salgado[2], J. C., Suita[2]
e-mail: bianca_lamarca@ien.gov.br, otero@ien.gov.br, suita@ien.gov.br

[1]CENS, IEN; [2]DIRA, IEN

Keywords: neutron shielding, MCNP-X code, particle accelerator, Cyclotron CV-28

The Instituto de Engenharia Nuclear (IEN) is a major radiopharmaceuticals producer. These are radioisotope bonded with chemical compounds, for the purpose to radiodiagnosis, therapeutical and monitoring in nuclear medicine procedures. Iodine-123 is one of the most relevant produced at Divisão de Radiofármacos, (DIRA-IEN).
This product is mainly absorbed by the thyroid cells, being used for diagnosis and follow-up of organ change. With a half-life about 13.2 hours, this logistic distribution fits the requirements for the Brazilian nuclear medicine.
The IEN´s CV-28 Cyclotron is the particle accelerator used for the production of ultrapure Iodine-123. There are 7 secondary lines in CV-28, with 4 of them installed inside the cyclotron cave, and 3 in external target-caves. To produce the ultrapure Iodine-123 is used the external transport line number 5.
The 24 MeV proton beam $({}^{1}_{1}H)$ is conducted to irradiate a Xenon-124 target, with an electrical current of 20 µA. The CV-28 is a multi-particle accelerator used also in research purposes, once is capable to produce many radionuclides [1]. There is an instability by the proton excess in nuclides, and then a positron (+β) is emitted by the nucleus, or an Electron Capture (EC) occur with the emission of gamma radiation (^{123}I), following the reaction, see Equation 1:

$$ {}^{124}_{54}Xe\ (p, 2n)\ {}^{123}_{55}Cs \rightarrow {}^{123}_{54}Xe \rightarrow {}^{123}_{55}I \quad (1) $$

During the irradiation, procedure in the iodine-123 target chamber, the emission of fast neutrons and gamma radiation with high energies occur as a product of nuclear interactions. The target cave is designed to shield radiation from nuclear reactions, minimizing dose levels in the external area, in accordance with the limits established in the CNEN standard regulatory [2]. In the access door, there is a need for a shielding block consisting of layers of concrete, lead and borated polyethylene to make the shielding, but, actually, it does not meet the minimum exposure limits of Norma 3.01 in some specific points of the installations [2]. The displacement of the block is done manually, see Figure 1.

Figure 1. Shielding block

This project presents a methodology to optimize the radiological protection, cost and weight of the shielding block that is installed at the front of the access door of the 5 line, reducing the dose in Occupationally Exposed Individuals (OEI) and the Public to the level as low as possible. The problem in question is being developed by analyzing possible materials and thicknesses capable of moderating, capturing and absorbing neutrons by means of mathematical models using simulations with the MCNP-X code.
The mathematical method will be experimentally validated by neutron activation detectors. Three plates of materials that have different cross sections (activation threshold) will be used. The neutron field will induce nuclear reactions in the activation detectors, emitting gamma radiation. These detectors will be counted by a HpGe detector.

References

[1] TCC. **Cyclotron service and operation manual.** The cyclotron corporation, [S. l.], 1973.
[2] BRASIL. Ministério da Ciência e Tecnologia. Comissão Nacional de Energia Nuclear. Resolução Nº 164, de 7 de março de 2014. Dispõe sobre a alteração do item 5.4.3.1 da Norma CNEN NN 3.01 Diretrizes Básicas de Proteção Radiológica, que define a otimização médica da proteção radiológica aplicável à área de medicina nuclear. Diretrizes básicas de proteção radiológica. **Diário Oficial [da] República Federativa do Brasil**. Brasília, DF, v. 47, Seção 1, p. 5, mar. 2014.