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Activation Analysis for Beam Dump of IF Facility in RAON Accelerator

Eun Joong Lee [a*], Cheol Woo Lee [b], Sung Chul Yang [b], Young-Ouk Lee [b], Gyuseong Cho [a]
[a]*Korea Advanced Institute of Science and Technology*
[b]*Korea Atomic Energy and Research Institute*
[*]*Corresponding author: leej0715@kaist.ac.kr*

1. Introduction

The RAON accelerator beams will provide primary beams on a fragmentation target in In-Flight (IF) separator system, and unreacted primary beam will be removed by the beam dump system. There are several types of primary beam. The maximum primary beam energy for ^{238}U beam is 400 MeV/u, 590MeV/u for ^{16}O, 550MeV/u for ^{48}Ca, ^{86}kr and ^{112}Sn. The beam power is 400kW in all particles [1]. During the operation, the beam dump components will be activated by the unreacted primary beam. The estimation of the induced radioactivity in an accelerator facility is particularly important for maintenance interventions and final disposal of radioactive waste [2,3]. In this study, the radioactivity of the radionuclides produced in the beam dump components and residual dose rate induced by the radionuclides are quantified.

2. Methods and Results

The induced radioactivity was estimated by two codes which MCNPX 2.7 and SP-FISPACT 2010. MCNPX is a particle transportation code and FISPACT is an activation analysis code. The track information of the primary beam was scored by the MCNPX and activation analysis was carried out by the SP-FISPACT. The dose rate also measured via MCNPX utilizing the gamma-rays emitted from the radionuclides that calculated by the FISPACT.

The beam dump consists of three components, titanium (Ti), water and stainless steel (ST304). A conceptual drawing of the water-filled rotating beam dump is illustrated in Fig.1. The outside diameter is 60 cm and titanium shell was set to 1mm. The depth of water chamber is 10 cm [4].

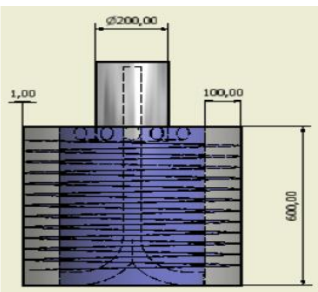

Fig. 1. The conceptual drawing of the water-filled beam dump

The activation analysis was carried out with the primary beam that ^{16}O, ^{48}Ca, ^{86}kr, ^{112}Sn and ^{238}U. The activities of the beam dump injected by ^{238}U beam is presented in following figures as a function of operation time and cooling time in each component. Significant radionuclides are illustrated in following figures. The activity calculation was performed for 5000 hours of irradiation with ^{238}U at 400 MeV/u, 400 kW. 5000 hours are an expected operation time in a year. The activity was scored every 100 hours. After the irradiation, activity was estimated at several cooling times up to 1 year which 1 s, 10 m, 30 m, 1 h, 8 h, 1 d, 1 w, 30 d and 1 y. Fig.2 to Fig.4 shows activities in each beam dump components and Fig.5 for dose rate during the operation, Fig.6 to Fig.8 illustrates the activities and Fig.9 for dose rate as a function of cooling times.

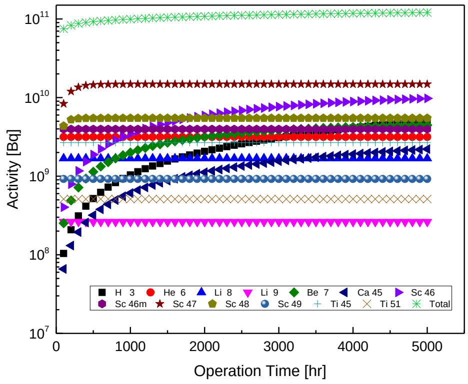

Fig.2. Activities of radionuclides produced in titanium during the operation.

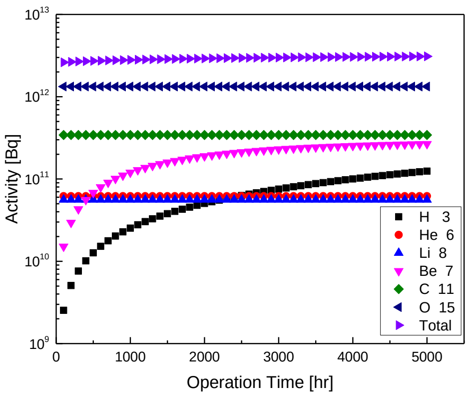

Fig.3. Activities of radionuclides produced in water during the operation.

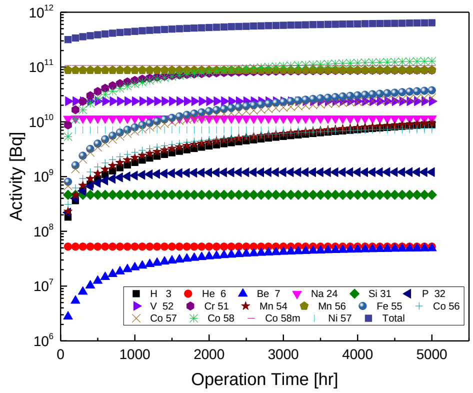

Fig.4. Activities of radionuclides produced in ST304 during the operation.

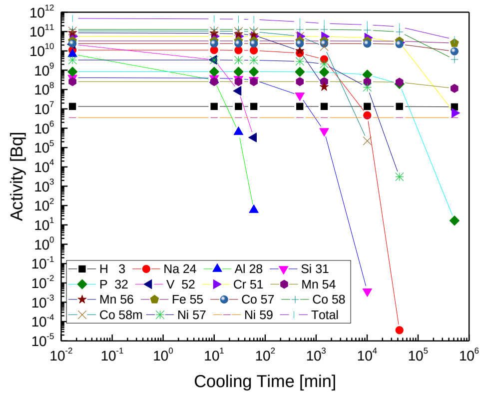

Fig.7. Activities of radionuclides produced in water as a function of cooling time.

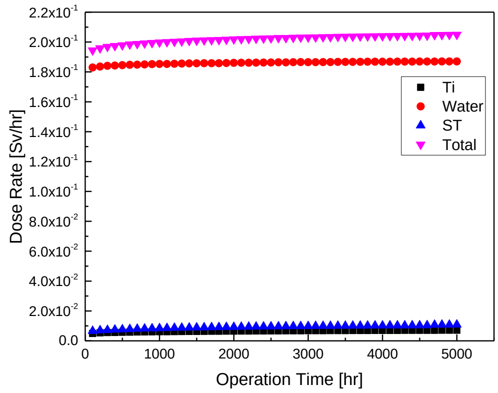

Fig.5. Dose rates from each component during the operation

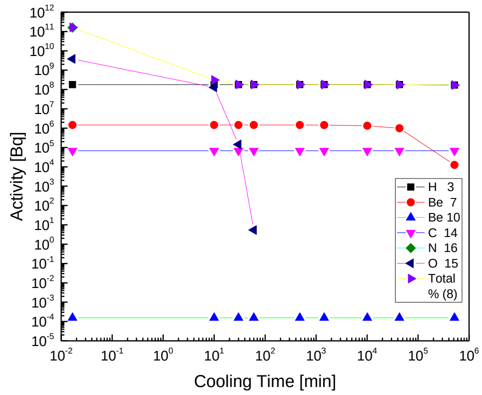

Fig.8. Activities of radionuclides produced in ST304 as a function of cooling time.

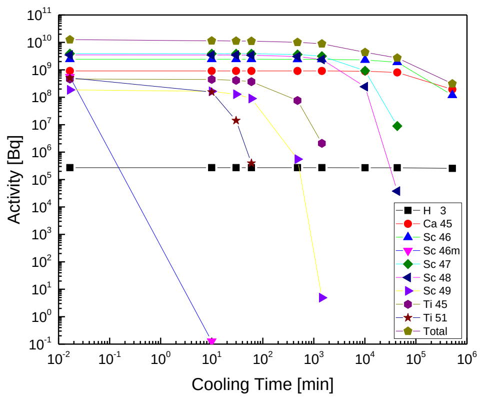

Fig.6. Activities of radionuclides produced in titanium as a function of cooling time.

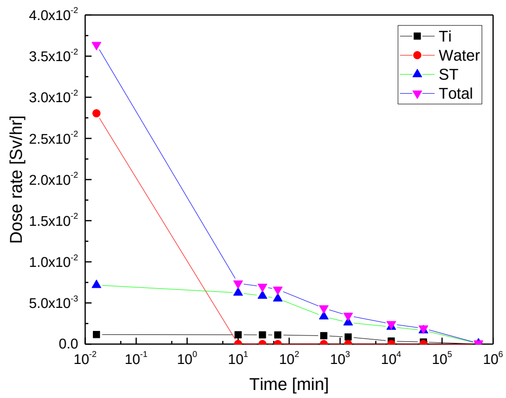

Fig.9. Dose rates from each component as a function of cooling time.

3. Conclusions

The quantitative information about the radioactivity in the beam dump of the IF facility in RAON accelerator complex was obtained through the simulations. Activities of the radionuclides and dose rates were estimated. With the ^{238}U as a primary beam, 191, 253 and 129 types of radionuclides were produced in titanium, water and ST304. During the operation, the dose rate was increased up to 0.2 Sv/hr and decreased after shutdown. Activation information of the ^{16}O, ^{48}Ca, ^{86}kr and ^{112}Sn would be introduced later. Furthermore, in the real situation, the cooling water in the beam dump circulates the cooling circuit and could be causes the radiation exposure outside the beam dump. Disposal plan such as filtering and dilution would be set through the further study.

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