Transactions of the Korean Nuclear Society Autumn Meeting
Pyeongchang, Korea, October 30-31, 2014

Activation analysis for the IFF system in RAON facility

Cheol Woo LEE [a*], Young-Ouk LEE [a], Jong Won KIM [b], Mijung KIM[b]
[a]*Korea Atomic Energy Research Institute, Daeduck-daero 989, Yuseong-gu, Daejeon, Korea*
[b]*Institute for Basic Science, Yuseong-daero 1689, Yuseong-gu, Daejeon, Korea*
[*]*Corresponding author: cwl@kaeri.re.kr*

1. Introduction

A heavy-ion accelerator facility is under a development in Korea to use in the basic science research and various application areas. In this facility, the In-Flight Fragment (IFF) target and isotope separator has been designed to produce various isotopes and transport the interesting isotopes into the experimental rooms. In this work, activation analysis for the pre-separator was performed in the IFF target room[1].

2. Radiation Source Terms

The radiation source terms were evaluated by using PHITS code[2]. The uranium and xenon beam with the energy range from 200 MeV/u to 400 MeV/u and the bam power of 400 kW were applied as the heavy-ion beam source. The simple graphite targets with various thicknesses were applied as target models. The calculation models of target assembly and beam dump based on the IFF equipment and beam dump design were also considered in the evaluation of the radiation source term. The secondary neutron spectrum in each angle from 0^{o} to 180^{o} was evaluated as the radiation source term for shielding analysis.

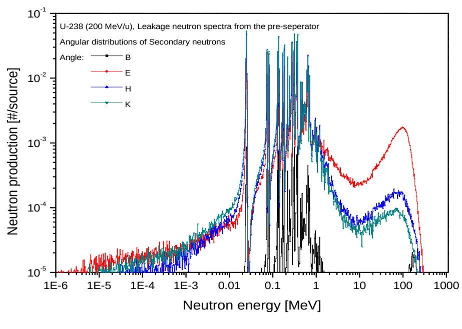

Fig. 1. Energy-angle distributions of secondary neutrons from U-238 beam of 200 MeV/u on pre-separator

3. Induced activities of the irradiated pre-separator

The calculation model for pre-separator, consists of the target producing isotopes, collimator, dipoles, quadrupoles, and beam dump. Induced activities in all components of the pre-separator were calculated using the activation code system which is consist of PHITS, MCNPX and DCAHIN/SP codes [2],[3]. 3000 hours of irradiation time was assumed in the estimation of activities.

Production of isotopes from the graphite target was valuated with the nuclear chart as shown in Fig. 2.

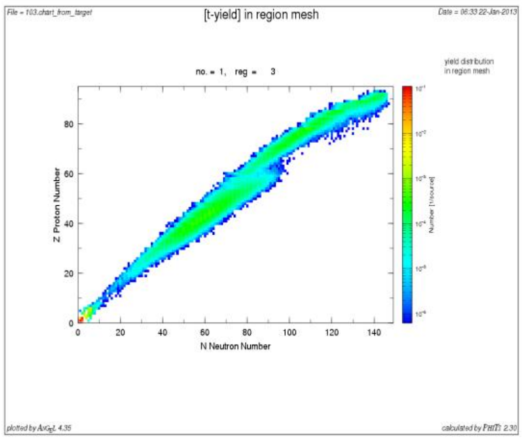

Fig. 2. Nuclear chart of isotopes produced from target

Induced activity in each component was described from Fig. 3 to Fig. 6 and total activity according to the cooling time after an operation of 3000 hours was shown in Fig. 7.

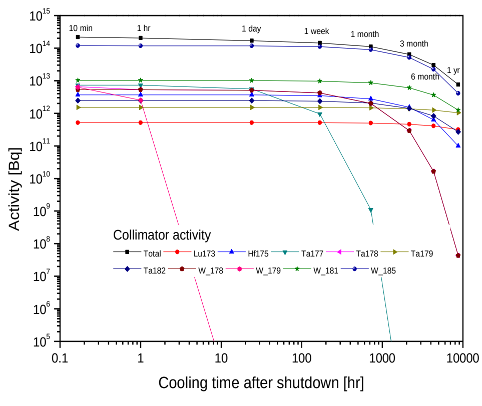

Fig. 3. Activities in the collimator according to the cooling time after an irradiation of 3000 hours

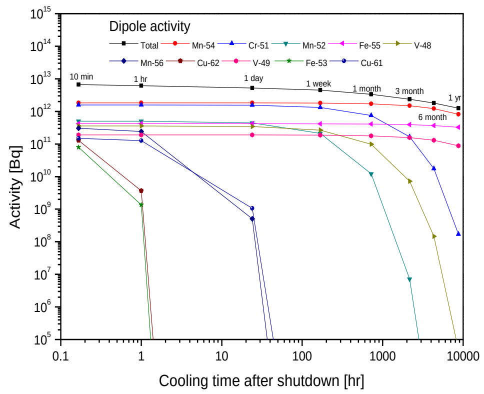

Fig. 4. Activities in the dipoles according to the cooling time after an irradiation of 3000 hours

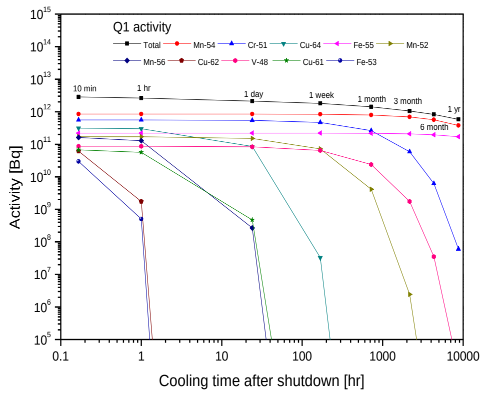

Fig. 5. Activities in the quadrupoles according to the cooling time after an irradiation of 3000 hours

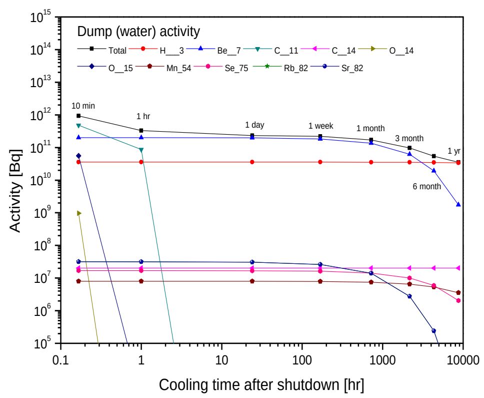

Fig. 6. Activities in the water beam dump according to the cooling time after an irradiation of 3000 hours

4. Estimation of Dose Distributions after a shutdown

The dose distribution after a shutdown was evaluated based on the activation of the IFF target equipment. Induced activity of the IFF target equipment during an operation was evaluated with the designed heavy-ion beam and the design of the IFF target equipment.

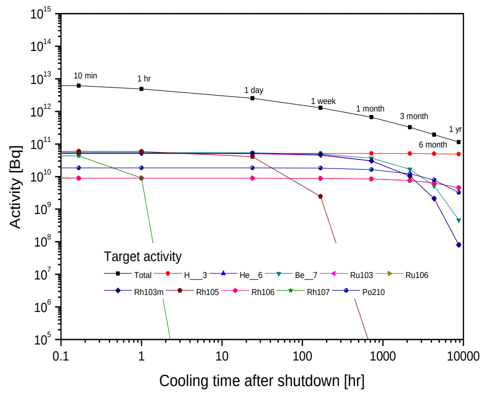

Fig. 7. Total activity of pre-separator according to the cooling time after an irradiation of 3000 hours

From the results of activation calculation, decay gamma-ray spectra produced in each component of IFF target equipment after a shutdown were estimated. The dose distribution inside target room after a shutdown was evaluated with the decay gamma-ray source term and the additional shields around IFF target equipment was considered to reduce the dose level inside target room after a shutdown. Fig. 8 shows the contributions of each irradiated component to decay gamma dose.

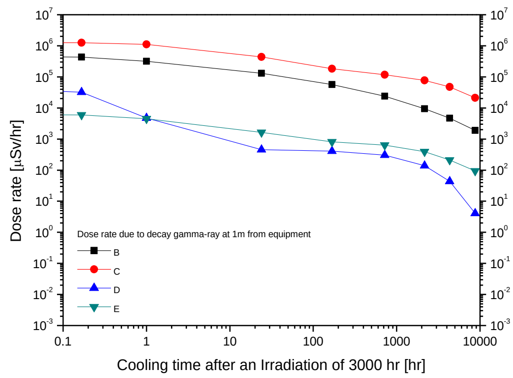

Fig. 3. Dose rate due to decay gamma-rays from the pre-separator according to cooling time after an irradiation during 3000 hours

6. Summary

In this work, activation analysis for the pre-separator was performed for the IFF target system in RAON heavy-ion accelerator facility. At first, radiation source terms were evaluated with the primary beams and target conditions. Using the evaluated source terms, induced activities in all component of pre-separator were calculated. The decay gamma-rays produced after a shutdown was estimated based on the activation analysis and gamma-ray dose rate according to the cooling time was evaluated.

REFERENCES

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[3] Denise B. Pelowitz, et. al., MCNPX User's Manual, LA-CP-05-0369, LANL, 2005.