Radiation Shielding for the Fast Neutron Generation Facility

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1. Introduction

The fast neutron generation facility based on a recently developed D-D neutron generator [1] is being constructed at Seoul National University. The fast neutron generation facility will be used for research and education of undergraduate and graduate students. In this study, the radiation shield was designed and analyzed.

2. Radiation Shielding Design

Layout of the fast neutron generation facility is as shown in Fig. 1. The fast neutron generation facility is allocated at the basement, whose dimension is 910 cm(L) ×670 cm(W)×225 cm(H). The facility is divided into two compartments of fast neutron generation and nuclear detection. The D-D neutron generator is installed in the fast neutron generation section, which is enclosed with the polyethylene(PE) and the borated polyethylene (BPE). PE is used to slow down the fast neutrons and BPE is used to capture the thermalized neutrons. The thicknesses of the PE panels are 36.5 cm, 35 cm, 6 cm at roof, surrounding wall and bottom, respectively. And the thickness of the BPE panels is 5.4 cm. Two sliding doors are installed at the neutron shield. There are four holes at the neutron shield to supply electric power, cooling water, etc. Secondary γ-rays from the neutron capture reactions are shielded by the lead-lined concrete wall. The thickness of the concrete wall is 20 cm, which is lined with 0.5 cm thick lead. A supplemental 2 cm thick lead shield is installed on the ground floor.

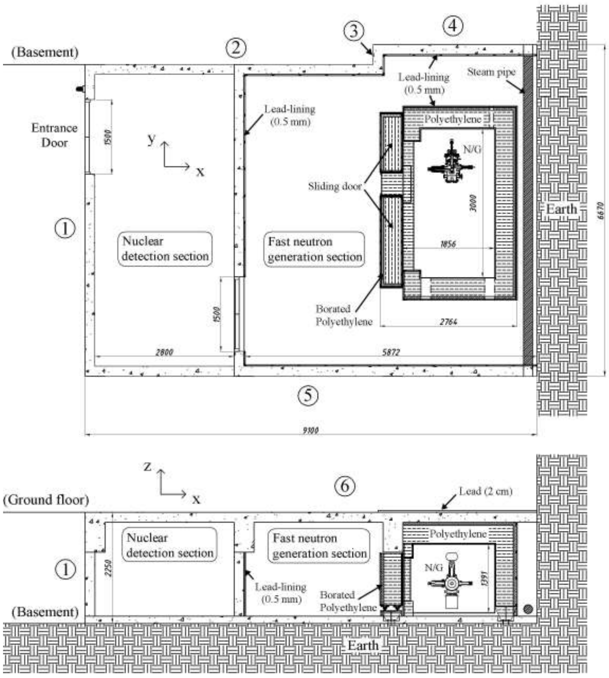

Fig. 1. Layout of the fast neutron generation facility (N/G : neutron generator)

3. Radiation Dose Rate Calculation

The radiation transport code MCNP4C [2] is used in this study. The assumptions and conditions for the calculation are as follows:

1) Neutron energy : 2.5 MeV
2) Neutron generation rate : 10^9 n/s
3) Facility operation : 40 hrs/week

The interaction cross sections of the neutron and photon are taken from the endf60 and mcplib02 libraries [2] which are the basic libraries of the MCNP4C code. Six surfaces indicated in Fig. 1 (① ~ ⑥) are the region of interest for the radiation dose rate calculation. The mesh tally is used for the calculation and the size of mesh is 10×10×1 [cm^3] (rectangular). The number of the mesh tally is 10,712. Neutron and photon fluxes are converted to radiation dose rates by using the ANSI/ANS flux-to-dose conversion factors [3]. Histories of neutron and photon are 1.5×10^8.

The result of the calculation is as shown in table 1. Among the listed surfaces, surface ⑥ which is located at the ground floor has the highest radiation dose rate. A contour plot of the radiation dose rate at surface ⑥ is shown in Fig. 2. The radiation dose rate is peaked at the

Table 1. Result of the radiation dose rate calculation

Surface	Maximum radiation dose rate [μSv/h]		
	Neutron	Photon	Total
①	0.29±0.14	0.11±0.01	0.40±0.14
②	0.41±0.23	0.50±0.04	0.91±0.23
③	0.30±0.27	0.56±0.05	0.86±0.27
④	0.51±0.50	1.25±0.05	1.76±0.50
⑤	0.66±0.24	0.60±0.04	1.26±0.24
⑥	0.45±0.42	1.42±0.07	1.87±0.43

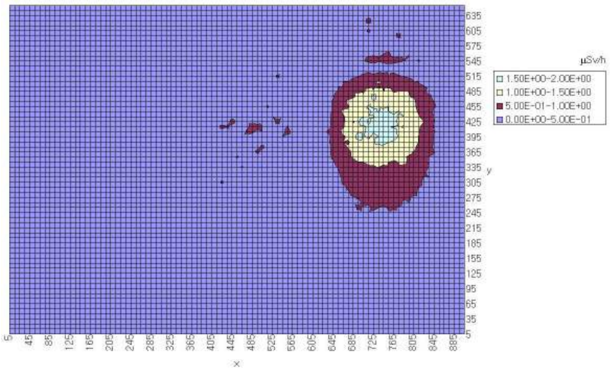

Fig. 2. Contour plot of the radiation dose rate calculated at surface ⑥, the surface of the ground floor

target center of the neutron generator projected to the surface ⑥ and it is 1.87±0.43 μSv/h. Considering the statistical error of the calculation, the radiation dose rate will not exceed 2.5 μSv/h which is the dose limit in the area adjacent to the boundary of the utilization facilities [4].

4. Conclusion

The radiation shielding for a fast neutron generation facility is designed based on an analysis by using the MCNP4C code. The calculated radiation dose rate is peaked at the target center of the neutron generator projected to the surface of the ground floor. However it is 1.87±0.43 μSv/h which is less than the dose limit in the area adjacent to the boundary of the utilization facilities

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