Shielding Assessment for Cyclotron Production Facility Using Monte Carlo Method

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1. Introduction

As the beam test facility of 13MeV cyclotron to produce a radioactive isotope is to be constructed, it needs to carry out shielding assessment for the facility in order to ensure safety for workers and public. In this study, Monte Carlo method was used in the shielding assessment for cyclotron beam test facility to secure high accuracy.

After the detailed modeling of the whole facility and cyclotron using MCNPX Code [1], dose calculations were performed at the outer of facility.

2. MCNP Modeling and Calculation Method

2.1 Design and Modeling of Whole Facility

The beam test facility of 13MeV cyclotron is described in Figure 1. All of the walls in this facility were made of normal concrete. The dimension of room containing cyclotron, whose size is 245.6cm × 130cm × 158cm, is 445.6cm × 530cm × 300cm.

The geometrical shape of graphite duct target was made to cylindrical one whose radius and length are 20cm and 40cm, respectively. Duct has cylindrical shape filled with void whose radius and length are 10cm and 20cm, respectively.

When the cyclotron is shown from direction A in Figure 1, the concrete thickness of left, right, front, rear, upper, and bottom are designed to 75cm, 50cm, 75cm, 75cm, 50cm, and 30cm, respectively, in this work.

Door was made of lead, and width, length, and thickness are 100cm, 200cm, and 5cm, respectively.

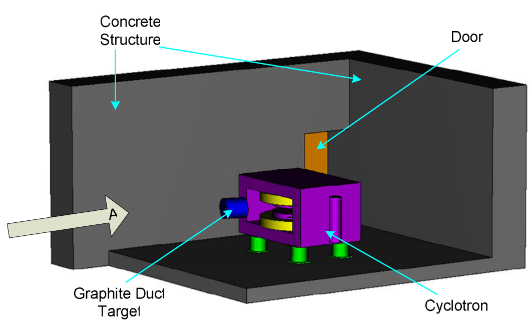

Figure 1. View of the Cyclotron Beam Test Facility

2.2 Modeling of Radiation Source

A proton beam generated from cyclotron was modeled as pencil-shaped beam with 13MeV energy. This beam is irradiated on the graphite duct target positioned in the place represented in Figure 2. This feature was established in the MCNPX modeling.

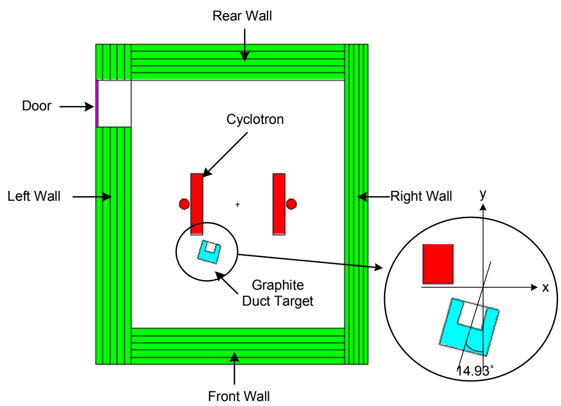

Figure 2. Horizon View of the Cyclotron Beam Test Facility

2.3 Calculation Method

When a proton beam is irradiated on graphite duct, neutrons and photons are produced. Dose rates for these two radiations were respectively calculated at outside of all the concrete walls except bottom wall. Total dose rates were obtained by summing up the two results.

Neutron and photon dose rates were calculated as flux multiplied by flux-to-dose conversion factors. ANSI/ANS-6.1.1-1991 neutron and photon dose functions for A-P direction (Anterior- Posterior) were employed to convert the neutron and photon flux into dose.

3. Results and Discussions

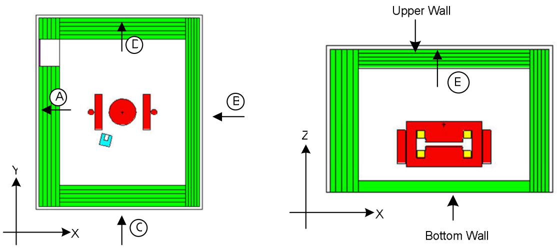

Figure 3. Direction of Views of Dose Rates Map

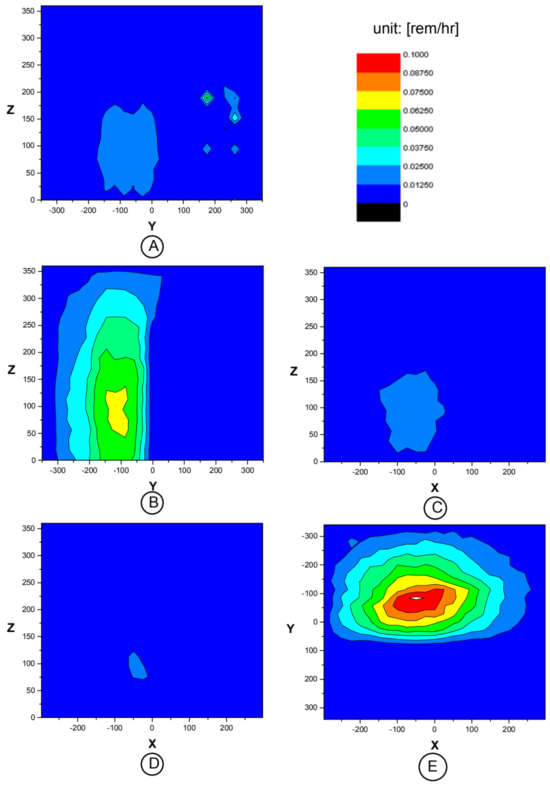

Figure 4. Dose Rates Results

It was assumed that a cyclotron was operated during 5 days a week and 60 seconds a day.

Figure 3 shows a direction of views of dose rates maps, presented in Figure 4, on outer surface of each wall.

High dose rates were shown on right and upper walls. This might be caused by that the thickness of right and upper concrete walls is thin compared to other wall thickness.

It was found that all the calculation results were sufficiently satisfied with the dose limit of 0.12 rem/hr based on the Atomic Energy Act in Korea.

4. Conclusions

In this work, shielding assessment was carried out for the beam test facility of 13MeV cyclotron to produce a radioactive isotope with MCNPX Code. All the calculation results were satisfied with the dose limit to be requested. It is, therefore, noted that the cyclotron beam test facility will be operated safely when the concrete wall thickness to be designed and proposed in this work was applied.

The results of this work can be applied as a validation tool for the safety regulation and approval for the system.

Acknowledgment

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REFERENCES

[1] Laurie Waters, Ed., "MCNPX User's Manual, Version 2.4.0," LA-CP-02-408, Los Alamos National Laboratory, September 2002.