Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 29-30, 2014

Shielding structure analysis for LSDS facility

Choi Hong Yeop *, Kim Jeong Dong , Lee Yong Deok , Kim Ho Dong
Korea Atomic Energy Research Institute(KAERI)
1045 Daedeok-daero, Yuseong-gu, Daejeon, Korea
**Corresponding author: chy119@kaeri.re.kr*

1. Introduction

The LSDS (Lead Slowing Down Spectrometer) system is a cutting edge nuclear material measurement technique, being developed to analyze isotope, which are nuclear materials, through the spent fuel and pyro-process. [1.2] A LSDS system is a highly efficient technique in isotopic nuclear material content analysis. The nuclear material (Pyro, Spent nuclear fuel) itself and the target material to generate neutrons is the LSDS system for isotopic fissile assay release of high intensity neutron and gamma rays. [3.4]

This research was performed to shield from various strong radiation. A shielding evaluation was carried out with a facilities model of LSDS system. The MCNPX 2.5 code [5] was used and a shielding evaluation was performed for the shielding structure and location. The radiation dose based on the hole structure and location of the wall was evaluated. The shielding evaluation was performed to satisfy the safety standard for a normal person (1 μSv/h) and to use enough interior space. [6]

2. Methods and Results

2.1 Shielding Structure

The dose rate was fixed at 50 cm of concrete, and 5 cm of Borax, and evaluated. The shielding material was arranged in another location, as shown in Fig. 1.

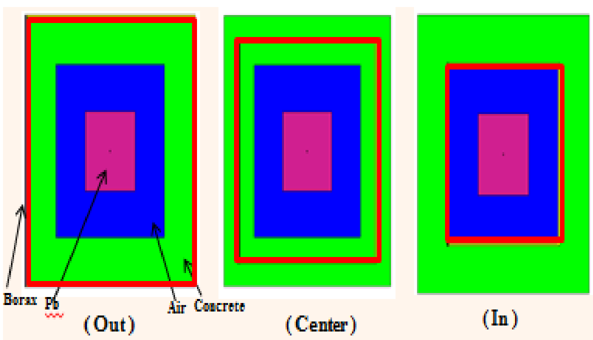

Fig. 1.Shielding structure

The evaluation result differs according to the location of the shielding material (Out: 2.18667E-02 μSv/hr, Center: 6.75835E-03 μSv/hr, In: 8.30285E-01 μSv/hr).

The dose rate was small when the shielding material was positioned at the center.

2.2 Facility Model Dose Evaluation

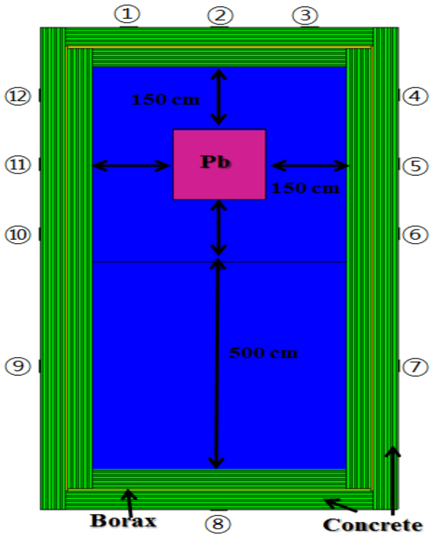

Fig. 2. Facility model

The dose evaluation result of the simple model was applied to the facility and the dose evaluation was performed. The system (spectrometer, target, and electron generator) was comprised as shown in Fig. 2 and the shielding dose was evaluated. The cell was made in the outside wall of the building. The shielding evaluation was performed about each spot.

Table I: Facility location dose rate

	Concrete dose rate (μSv/h)		
Tally number	**In 50cm +Borax 5cm + Out 45cm**	In 45cm + Borax 5cm + Out 45cm	In 45cm + Borax 5cm + Out 50cm
①	**1.46794E-02**	4.11199E-02	2.53115E-02
②	**4.42601E-02**	1.23631E-01	7.61028E-02
③	**1.45045E-02**	4.07041E-02	2.51123E-02
④	**1.48434E-02**	4.12253E-02	2.58246E-02
⑤	**4.37704E-02**	1.22498E-01	7.49558E-02
⑥	**1.31053E-02**	3.78217E-02	2.35574E-02
⑦	**2.21010E-03**	6.42351E-03	3.97643E-03
⑧	**4.86458E-03**	1.32055E-02	8.18003E-03
⑨	**2.30575E-03**	6.90096E-03	4.20278E-03
⑩	**1.32619E-02**	3.82628E-02	2.36326E-02
⑪	**4.37828E-02**	1.22055E-01	7.50638E-02
⑫	**1.44270E-02**	4.15348E-02	2.57923E-02

Table I indicates the dose results for each location. In Table I, the dose was satisfied in the internal 50 cm + borax 5 cm + outside 45 cm concrete. The inner concrete thickness was more sensitive than the outer.

2.3 Hole Structure

To prevent a radiation leak, the lab should be hermetic. However, a minimum hole is needed for numerous electrical wires and the inner ventilation.

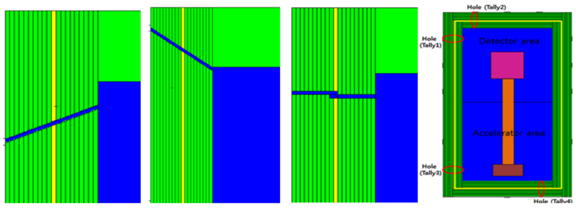

Fig. 3. Hole structure model

In the existing hole structure, the radiation leak is higher than the standard. To prevent a radiation leak, the hole structure model has been proposed, as in Fig. 3.

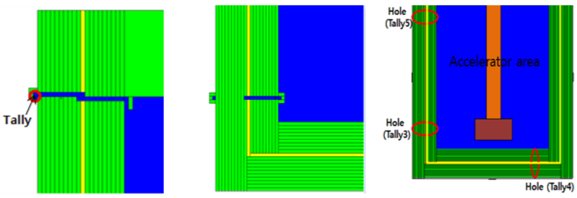

Fig. 4. Supplemented hole structure

The shielding evaluation result was unable to satisfy the general public dose limit. Therefore, the concrete was reinforced in the hole insides and outside, as shown in Fig. 4.

Table Ⅱ: Hole location dose

	Structure	Tally5 Flux (μ Sv/h)	Tally3 Flux (μ Sv/h)	Tally4 Flux (μ Sv/h)
일반 Concrete	Shielding Zigzag	6.3545E-03	3.3161E-03	4.5537E-03
Heavy Concrete	Shielding Zigzag	8.7012E-03	4.2914E-03	7.4073E-03

The dose results are shown in Table Ⅱ. The general public dose limit is satisfied by way of reinforcement of the concrete from all locations.

3. Conclusions

The MCNPX2.5 code was used and a dose evaluation was performed for the location of the shielding material, shielding structure, and hole structure.

The evaluation result differs according to the shielding material location. The dose rate was small when the shielding material was positioned at the center.

The dose evaluation result regarding the location of the shielding material was applied to the facility and the shielding thickness was determined (In 50 cm + Borax 5 cm + Out 45cm).

In the existing hole structure, the radiation leak is higher than the standard. A hole structure model to prevent leakage of radiation was proposed. The general public dose limit was satisfied when using the concrete reinforcement and a zigzag structure.

The shielding result will be of help to the facility shielding optimization.

ACKNOWLEDGEMENT

This work was supported by the Nuclear Research Foundation of Korea (NRF) grant funded by the Korea government(MSIP) (No. 2013036069).

REFERENCES

[1] Y.D. Lee, N.M. Abdurrahman, R.C. Block, D.R. Harris, and R.E. Slovacek, “Design of a Spent-Fuel Assay Device Using a Lead Spectrometer,” Nucl. Sci. Eng., 131, 45, 1999.

[2] D. Rochman, R.C. Haight, J.M. O'Donnel, A. Michaudon, S.A. Wender, D.J. Vieira, E.M. Bond, T.A. Bredeweg, A. Kronenberg, J.B. Wilhelmy, T. Ethvignot, T. Granier, M. Petit, and Y. Danon, "Characteristics of a Lead Slowing-Down Spectrometer Coupled to the LANSCE Accelerator," Nuclear Instruments and Methods in Physical Research A, 550, 397, 2005.

[3] H. Krinninger, E. Ruppert, and H. Siefkes, "Operational for Nuclear Safeguards," Nucl. Instr. Methods, 117, 61, 1974.

[4] N. Baltateanu, M. Jurba, V. Calian, G. Stoenescu, "Optimal Fast Neutron Sources Using Linear Electron Accelerators," Proceedings of EPAC 2000, pp.2591-2593, Vienna, Austria 2000.

[5] D.B. Pelowitz, MCNPX User’s Manual, LA-CP-05-0369, Los Alamos National Laboratory, 2005.

[6] Y.D. Lee, H.Y Choi, J.D. Kim, C.J Park, "Neutron detector performance evaluation and Shielding element analysis", KAERI/ TR-4854/ 2013