Evaluation of Shielding Wall Optimization in Lead Slowing Down Spectrometer System

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1. Introduction

A Lead Slowing Down Spectrometer (LSDS) system is nondestructive technology for analyzing isotope fissile content in spent fuel and pyro processed material, in real time and directly [1]. The high intensity neutron and gamma ray were generated from a nuclear material (Pyro, Spent nuclear fuel), electron beam-target reaction and fission of fissile material. Therefore, shielding analysis of LSDS system should be carried out.

The shielding wall be composed of sandwich structure that concrete-borax-concrete (50cn+5cm+45cm) had been designed for LSDS system [2]. In this study, the covering (250cm x 250cm) was set up around the spectrometer as a way to reduce the thickness of the shielding wall and to complete the effective shield structure. A shielding analysis was carried out to optimize the shielding wall thickness using MCNP6 code [3].

2. Experimental Procedure and Results

2.1 Covering Placement and Shielding Wall Structure

The Spectrometer is composed of a 170cm x 170cm lead module. The target is located in the center of the spectrometer [4]. The distance between the spectrometer and the shielding wall is 150cm. When selecting the location of the covering, it was considered that a sufficient space from the shielding walls to the outer covering and a reflectivity of covering. At the same time, the reflectivity less than 1% was considered. Fig.1 shows the covering geometry, the covering is located 50cm away from the spectrometer.

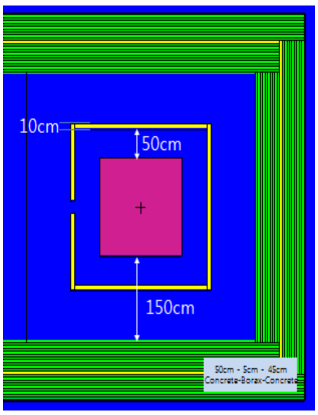

Fig. 1. Covering geometry.

2.2 Covering Structure

The covering thickness, position, and materials were determined through dose assessment except for the passage for the electron beam to be incident on the spectrometer. The thickness of shielding wall 5cm, 10cm with Borax, B_4C, Li_2Co_3, Resin were simulated for shielding analysis. The results of dose rate were shown in Table I.

Table I: Covering thickness evaluation (μSv/hr)

	Material	Left Wall	Right Wall	Up wall
Reference	No covering	4.43E-2	5.05E-2	4.91E-2
Thickness (5cm)	HDPE-Borax	1.24E-2	1.79E-2	1.45E-2
	B_4C	9.25E-3	1.04E-2	9.90E-3
	Li_2Co_3	2.78E-2	2.90E-2	2.92E-2
	Resin	1.22E-2	1.15E-2	1.11E-2
Thickness (10cm)	HDPE-Borax	5.51E-3	6.22E-3	5.90E-3
	B_4C	4.89E-3	4.52E-3	4.80E-3
	Li_2Co_3	1.94E-2	1.92E-2	2.10E-2
	Resin	6.63E-3	5.71E-3	5.92E-3

Table II shows the dose rate at the concrete outer wall with a double structure of the shielding covering. A single structure was found to be more effective than double structure. The appropriate thickness of covering was 10 cm when the shielding rate is high. The dose rate was low in the order of B_4C, HDPE-Borax, Resin and Li_2Co_3.

Table II: Double structure evaluation (μSv/hr)

Material	Thickness	Left Wall	Right Wall	Up wall
HDPE-Borax +Concrete	10 Cm	8.48E-03	7.37E-03	7.85E-03
B_4C +Concrete		5.68E-03	6.06E-03	5.14E-03
Resin +Concrete		9.68E-03	8.22E-03	9.85E-03

2.3 Dose Assessment for Shielding Wall Thickness

From the above results, the covering could be able to reduce the neutrons and gamma ray from the spectrometer. Therefore, the shielding analysis of LSDS system was carried out by adding the covering. The sensitivity analysis was performed by reducing inner and outer concrete thickness respectively, by 5cm with middle material of borax 5cm. Table III shows the dose rate by the shielding wall thickness.

Table III: Shielding wall dose rate (μSv/hr)

Thickness	Left	Right	Up	Down
0 cm	1.90E-03	1.62E-03	1.47E-03	1.60E-03
-5 cm	9.35E-03	5.64E-03	4.38E-03	5.09E-03
-10 cm	2.28E-02	2.71E-02	2.05E-02	2.32E-02
-15 cm	7.25E-02	6.69E-02	6.41E-02	5.18E-02

As shown in Table III, it could be seen that the dose rate increases with a very small according to reduced concrete thickness. It was able to reduce the thickness of shielding wall by providing the covering.

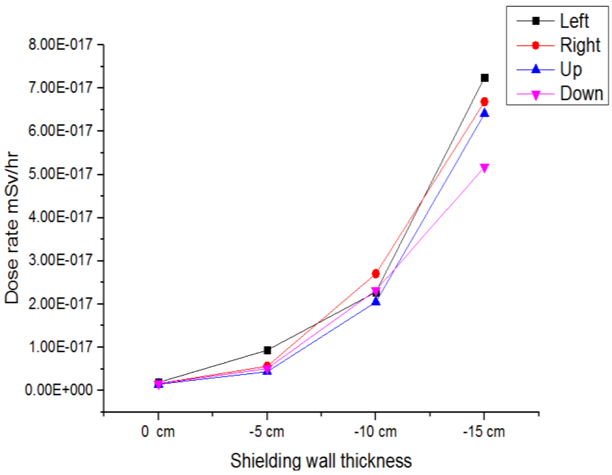

Fig. 2. Shielding wall thickness evaluation.

Fig.2 shows that the high dose rate was calculated at the right and left side of the shielding wall near the spectrometer. On the other hand, A down side of facility presents the lower dose rate because of the far distance from the spectrometer.

3. Conclusion

In this study, Borax, B_4C, Li_2Co_3, Resin were chosen for shielding analysis. The radiation dose limit (<0.1 μSv/hr) was adopted conservatively at the outer wall surface. The covering could be able to reduce the concrete wall thickness from 5cm to 15cm. The optimized shielding walls evaluation will be used as an important data for future real LSDS facility design and shielding door assessment.

ACKNOWLEDGMENTS

This work was supported by the Nuclear Research Foundation of Korea (NRF) grant funded by the Ministry of Science, ICT and future Planning (MSIP) of Korea under project (No. 2015032743).

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