Shielding Analysis of High Density Polyethylene and Borax for Lead Slowing Down Time Spectrometer System

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1. Introduction

A lead slowing down time spectrometer(LSDTS) system has been designed in order to analyze the contents of the special materials such as U-235, Pu-239, Pu-241[1][2]. However, the target in LSDTS emits a high intensity of neutron and gamma rays when operating. For example, a typical neutron yield of LSDTS is about 1E+12 neutrons/s[3][4]. In this study, a shielding evaluation was carried out with a simplified and real size model of the LSDTS system in order to protect neutron. The MCNPX code[5], a popular Monte Carlo three dimensional code, was used and this study was also performed for the shielding structure, thickness, materials and distance. Additionally, Variance reduction with geometric splitting technique was tried in order to get highly efficient results.

2. Methods and Results

Three parts were considered to evaluate the shielding analysis for LSDTS: Wall, ceiling, reinforced door. The medium of LSDTS is full of pure lead blocks, which provides an inherent radiation shielding effect.

The geometric splitting card, importance are assigned to each cell in the problem, were used in the MCNPX modeling to get computational efficiency. The point source was assumed to be positioned at the center in the Lead. The surface dose rate was converted from surface flux based on the ICRP-21 conversion factor sets.

All kinds of test were performed to keep the safety standard for the public.

2.1 Wall of HDPE+borax shielding

The real size model is depicted in Fig. 1. The shielding material is used for lead, HDPE+Borax, and concrete. The thickness of lead, concrete and HDPE+borax are 85 cm, 50 cm and 34 ~ 45 cm. Dose rate is observed as thickness of HDPE+Borax is changing from 34 cm to 45 cm in Fig. 2. The initial intensity of neutron was 1E+12 neutrons/s. Enough geometry splitting was taken to get high computational efficiency. The dose rate following distance was obtained in Fig. 2. The safety standard for the public is 0.1 μSv/h but in this study recommend 1/5 of the safety standard for the public to the conservative analysis. Therefore, shielding thickness of Borax in this system decided 35 cm

2.2 Ceiling of HDPE+borax shielding

The pure lead, HDPE+Borax and heavy concrete were considered for neutron shielding analysis. This model informed of how much the dose rate was changed when the HDPE+Borax was increased.

Table 1. shows the results for HDPE+Borax with various thicknesses. From the analysis, the dose rate is decreased in proportion to the increasing of HDPE+Borax thickness. So the shielding needs 15 cm of the borax when the concrete thickness is 100cm to get safe shielding dose rate. And if the borax is out of the concrete of 100 cm thickness, borax needs 2 cm. and also it needs 13 cm, 18cm when the concrete is 50 cm, 40 cm.

2.3 Reinforced door of HDPE+borax shielding

In door part, the shielding should be light and thin because the door has to move. The reinforced door model is depicted in Fig. 4. And Reinforced door is compared in those materials which is HDPE+borax, concrete, air. The efficiency of HDPE+borax was higher than the others.

Table 2. shows the results of the dose rate for various materials and position.

3. Conclusions

It was found that thickness of HDPE+borax is 35 cm to get under the public dose rate criterion in wall case when the dose rate is needed under 1/5 of the safety standard for the public to the conservative analysis.

And in ceiling case, thickness of HDPE+borax is 15 cm when the concrete is 100 cm. Besides, if the borax is outer surface of concrete, the thickness will be decreased.

Additionally, shielding calculation on beam loss, activation analysis and the optimum thickness of reinforced door after hot area will be performed.

ACKNOWLEDGEMENT

This work is performed under the auspices of Korea Ministry of Education, Science and Technology as a nuclear long-term R&D project.

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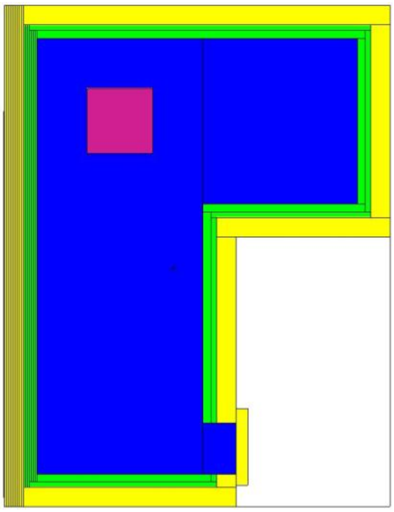

Fig.1. Configuration of neutron shielding problem.

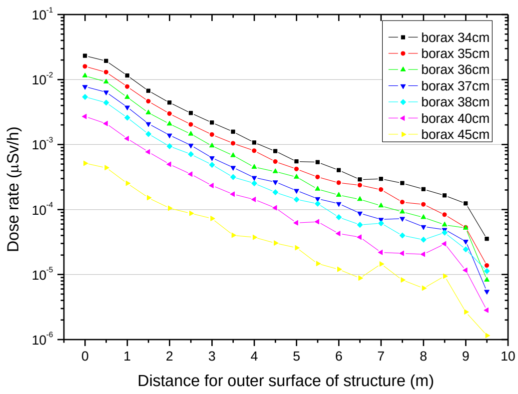

Fig.2. Dose rate following distance for outer surface of structure by HDPE+Borax thickness change.

HDPE+Borax (cm)	Mean (μSv/h)	Error
10	1.6281E-1	0.0103
15	3.1324E-2	0.0074
20	5.1660E-3	0.0103

Table 1. Dose rate following thickness of HDPE+Borax at ceiling part.

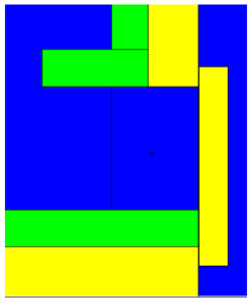

Fig.4. Configuration of door part of neutron shielding problem.

Reinforced shielding	Position	Dose rate (μSv/h)	Error
Air	Inner surface of door	4.07E+03	0.0069
	Outer surface of door	7.75E+01	0.0135
HDPE+Borax	Inner surface of door	2.01E+03	0.0236
	Outer surface of door	4.61E+01	0.0621
Concrete	Inner surface of door	2.24E+03	0.0261
	Outer surface of door	4.88E+01	0.0595

Table 2. Dose rate following reinforced neutron shielding material at door part.