Preliminary Shielding Analysis for Review of Multipurpose Utilization of PWR Spent Nuclear Fuel Disposal Canister

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1. Introduction

Most of countries are developing and using a variety types of Cask for efficient and safe management of Spent Nuclear Fuel (SNF). In particular, the Disposal Cask used in the final management phase provide a primary barrier to isolate spent fuel and maintains leak tightness in deep environments during its design lifetime to prevent leakage of internal radioactive nuclide.

There is no domestic technical standard for disposal casks and according to the overseas disposal cask shielding design requirement, the maximum absorbed dose rate in the surface structure of the disposal container must be kept below 1 Gy/h to prevent corrosion due to radiolytic products on the outer surface of the cask [1][2].

The purpose of this study is to evaluate the thickness of a multi - purpose canister for transport - storage - disposal that meets the shielding design standard, for bentonite used as a structure around the disposal cask.

2. Method and Assumption

2.1 General Information of disposal cask

The inserting channel of SNF was designed with a width of 23.5 cm and a height of 454.8 cm, which can facilitate WH fuel (width 21.4 cm, height 406 cm), and CE fuel (width of 20.7 cm, height of 453 cm). The loading capacity of SNF is 4 bundles to made of corrosion resistant copper outside and cask nodular iron inside.

2.2 General assumptions

Based on the study by the KORAD (Korea Radioactive Waste Management Corporation), the design basis fuel for the shielding analysis is selected as CE type PLUS7 with the initial concentration of 4.0%, the emission combustion of 45 GWD/MTU and the cooling period of 40 years [3].

The analytical conditions are as follows; finding absorbed dose rate of bentonite used as external structure of the disposal cask in the normal condition by increasing the thickness of the multi-purpose canister. The MCNP6 was used to evaluate the shielding. The relative error and reliability of the calculation results were confirmed by the 10 statistical errors provided in the MCNP6 output file.

2.3 Special assumptions

In this study, the IRON INSERT of the disposal cask in the previous research is named 'internal canister'. Furthermore, in order to utilize it for transportation or storage, some assumptions are established with its inside structural change as shown in Fig. 1.

- To reduce the weight, the inside of the canister was changed to an empty space, and the assembly basket filled with the fuel
- To alter material of the changed inner canister to stainless steel, and to maintain the upper thickness of 5 cm and the lower thickness of 8 cm.
- The cask shell is made of copper to maintain a proper thickness of 5 cm to prevent corrosion.
- For the above conditions, an SNF gap of 7cm and 78 cm in inner diameter satisfying the critical condition is applied.
- Calculation of the absorbed dose rate for bentonite,

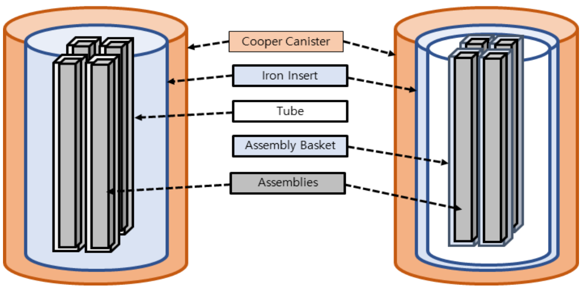
which is an outer structure of the disposal cask, is applied at a depth of 1cm.

3. Results

The calculated gamma - ray and neutron absorbed doses rate of bentonite on the top and bottom of the disposal cask were estimated to be 0.391 Gy/h and 0.00003 Gy/h, respectively. In case of the side thickness of the inner canister was 1 cm, the absorbed dose for gamma rays of the bentonite was 1.445 Gy/h and the neutron was 0.00005 Gy/h. The absorbed dose for 3 cm was estimated to be 0.627 Gy/h for gamma rays and 0.00004 Gy/h for neutrons. Finally, in case of the thickness of the inner canister is 4 cm, the absorbed dose is estimated to be 0.379 Gy/h for gamma rays and 0.00003 Gy/h for neutrons, which does not exceed the shielding design standard of 1 Gy/h Respectively.

4. Tables and Figures

4.1 Figures



(a) Original Model (b) Modification model

Fig. 1. Design modify of Disposal cask and Canister.

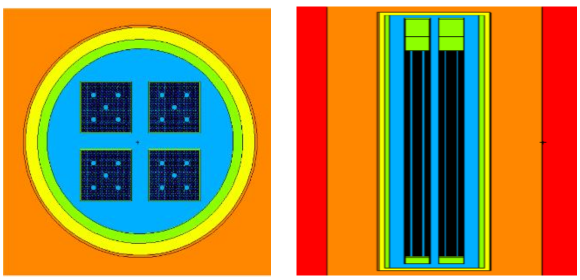


Fig. 2. MCNP modeling of Modification Model.

4.2 Table

Table 1. Absorbed dose of bentonite structure

[Unit : Gy/h]

	Width	Gamma ray	Neutron
Side	1 cm	1.445	0.00005
	2 cm	0.813	0.00004
	3 cm	0.627	0.00004
	4 cm	0.379	0.00003
Top & Bottom		0.391	0.00003

5. Conclusion

The preliminary shielding evaluation was carried out to examine the multi - purpose utilization by changing the internal structure of the 4 bundles disposal cask developed by the existing research. As a result of the evaluation, when the thickness of the inner canister was 3 to 4 cm, the absorbed dose to the side of the cask and the top & bottom bentonite did not exceed the design standard of 1 Gy/h.

With the Shielding analysis method, it is possible to derive the basic specifications of the canister meeting all the transportation, storage and disposal standards. Also, it is considered that the optimum multi-purpose canister can be developed by analyzing the heat and structure.

ACKNOWLEDGEMENT

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