The Study on Evaluation Method of Physical Inventory of Nuclear Fuel Cycle Facility

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1. Introduction

Decontamination and Decommissioning project of the nuclear facilities is one of the biggest projects in the world. It is very important to investigate and identify the characteristics of nuclear facility to be decommissioned in establishing a decommissioning plan for nuclear facilities. The characteristics data of the nuclear facilities to be decommissioned are used to predict the amount of waste and to estimate the expected dose for each facility during the decommissioning. [1]

In this study, a method for evaluating concrete inventory during the decommissioning was studied to evaluate the physical and radiological inventory of Post-Irradiation Examination Facility (PIEF).

2. Methods of evaluation for concrete inventory

PIEF is the first Hot cell laboratory in Korea to test nuclear fuel and nuclear materials including nuclear fuel reactors for domestic nuclear power plants. The PIEF is a reinforced concrete structure that can be divided into completely shielded cell parts and general structures. General concrete with a density of 2.3g/cm^3 and a compressive strength of 250kg/cm^2 are used in the general structure. Heavy concrete with a density of 3.5 g/cm^3 and a compressive strength of 281kg/cm^2 are used as shielded cell part. The physical inventory of PIEF concrete and the predicted waste quantities were evaluated and compared. Evaluation method of physical inventory is as follows.

First, we collected the name, capacity, quantity, size, specific gravity, volume, weight and material of the object for concrete inventory evaluation.

Second, we analyzed the specific inventory of each building through facility drawings, MCNP 3D modeling and license documents. If necessary, we visited the site and measured the size. Input data of MCNP modeling are shown in Table 1. Based on the input data as shown in Table 1, the volume of the space was calculated, and the weight of the material constituting the space was calculated using the material density data.

Table 1. Input data of MCNP modeling

Input data	
Coordinate	X, Y, Z
Components of space	Density, Element ratio
Source term	Energy, Dose

3. Results of evaluation

The input data for MCNP modeling requires the room size with the X, Y, and Z coordinates and the materials (component, density). 3D modeling was done after the drawing analysis and the results were visualized using VISED code.

Typically, Figure 1 and 2 show the layout of underground 1 floor of PIEF received from Korea Atomic Energy Research Institute (KAERI) and 2D modeling results of PIEF by MCNP. In the drawings (2D drawings), ordinary concrete is represented as red, heavy concrete as blue, and water tank as green. The simulation results show the total volume and mass by including material from each compartment in the MCNP input data. In this study, the volume and mass of each room were obtained, and the amount of concrete in each layer was calculated by multiplying the specific volume of normal concrete and heavy concrete by volume.

The decommissioning waste is divided into building waste and equipment waste. The building waste consists of concrete waste, metal doors and equipment wastes. In order to estimate radioactive waste from these wastes, the concrete surface is assumed to be 0.2 cm wall, 0.5 cm floor, and 0.1 cm ceiling by using scabbler. Based on these assumptions, it is calculated according to Equations (1), where Σ is the sum of each compartment and all the facilities surveyed.

$$\text{Total radioactive building dismantled waste quantity} = \Sigma \text{ Compartment area } (m^2) \times \text{Decontamination depth } (m) \times \text{Concrete density } (ton/m^3) \quad \text{......... (1)}$$

Tables 2 and 3 show the physical inventory and predicted waste for concrete in the PIEF building. The tables 2 and 3 show that there is not much difference between the physical inventory of concrete (about 16,513.8 tons) and the predicted amount of waste (about 15,890 tons). The results of evaluating the concrete inventory using the MCNP code are considered to be less error than the results of the evaluation using the facility drawings.

Among the total generated concrete (15,890.0tons), radioactive waste is 132.9 tons and is accounting for about 0.8% which has 16,750.0kBq calculated using Radiological Safety Control annual report from KAERI.[2] The amount of concrete generated by decontamination works such as the scabbling is very small. If converted to the allowable concentration, it is 0.13 Bq/g, which corresponds to the very low level waste (VLLW), which is 0.1Bq/g to over 100 times the Cs^{137} disposal concentration according to Notification No. 2014-3 of Nuclear Safety Commission. In other words, concrete waste, which accounts for the majority of dismantled waste, consists of its own disposal and very low level waste (VLLW).[1][2] Based on this, it can be seen that a lot of concrete dismantling, decontamination, and waste handling should be put more importance in decommissioning planning and decommissioning waste management work in future.

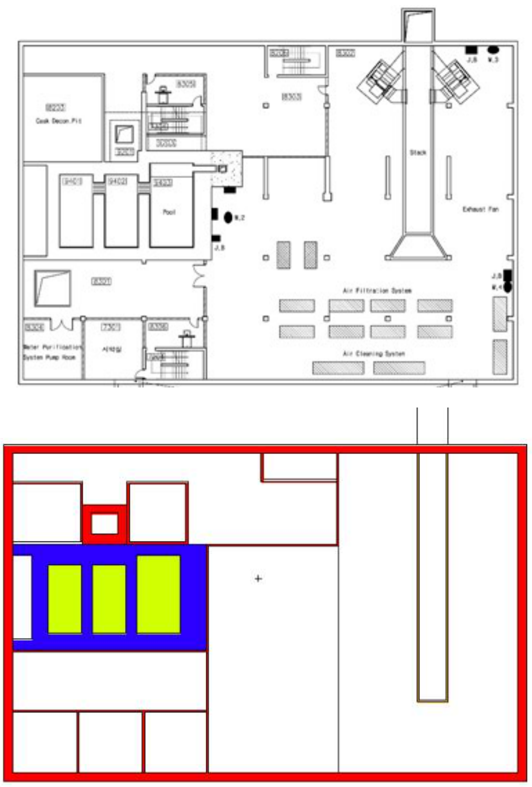

Fig. 1. Underground 1 floor drawings and 2D graphic result of PIEF

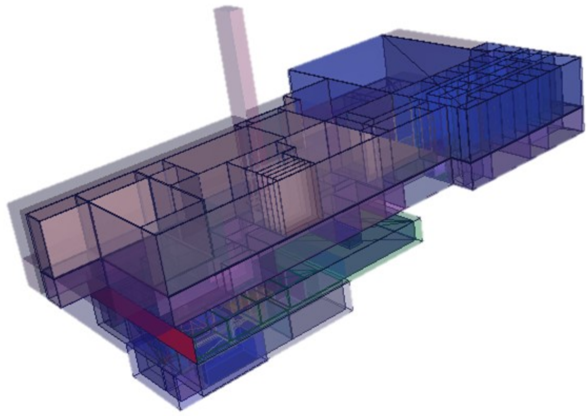

Fig. 2. MCNP modeling for whole view of PIEF

Table 2. Physical inventory of concrete in PIEF

Post-Irradiation Examination Facility(PIEF)	**Concrete (Ton)**	
	Ordinary	**Heavy**
1 basement level	4,078.6	1,407.3
2 basement level	2,276.8	1,950.7
3 basement level	2,036.6	0
1 floor	1,841.2	0
2 floor	2,922.5	0
Sum	13,155.8	3,358.0
	16,513.8	

Table 3. Estimated waste quantity for concrete in PIEF

Post-Irradiation Examination Facility(PIEF)	**Concrete (Ton)**	
	General	**Radioactive**
Estimated waste quantity	15,757.1	132.9
	15,890.0	

4. Conclusion

In this study, concrete inventory and decommissioning waste were evaluated by 3D modeling using MCNP code for PIEF buildings. In the future, we plan to evaluate the physical and radiological inventory of nuclear facilities (research reactors and related facilities, nuclear fuel cycle facilities and related facilities) including the PIEF.

These results can be processed by discretion, floor, and material, and these data will help disassembly strategies, personnel, and costs in dismantling the facility. In addition, it is possible to carry out systematic preparations for decommissioning projects that will occur in the future, and it can be expected to have a positive effect on exports of nuclear facilities and decommissioning projects through research and development, in accordance with international trends demanding decommissioning plans from the construction stage.

5. Acknowledgements

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