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The study on evaluation method of physical inventory of nuclear facilities

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1. Introduction

The Nuclear Safety Act (Article 28) of the Republic of Korea required the submission of a preliminary decommissioning plan for all nuclear facilities. KAERI also submitted a preliminary decommissioning plan for nuclear facilities in July 2018(Article 35). To do this, Physical inventory assessment was carried out and the results are described in this paper.

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 during the decommissioning.

In this study, a method for evaluating concrete inventory during the decommissioning was studied to evaluate the physical inventory of 6 Nuclear Facilities of KAERI. Also, Physical inventory evaluation are carried out using Excel program. 6 nuclear facilities are Table 1.

Facilities selected for physical inventory evaluation are located in Korea Atomic Energy Research Institute (KAERI). 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. RWTF and SWTF are facilities to treat generated radioactive wastes. NETF is a facility for evaporating and concentrating very low level radioactive liquid waste using solar heat and evaporation material. RWSF is a facility to storage generated radioactive wastes. AFSB is a facility for the research and development of HANARO fuel and advanced nuclear fuel such as new fuel, metal fuel, future fuel and particle fuel.

Table 1. Facilities selected for inventory evaluation

No.	Facility name
1	PIEF (Post Irradiation experiment Facility)
2	RWTF (Radioactive Waste Treatment Facility)
3	SWTF (Solidified Waste Treatment Facility)
4	NETF (Natural Evaporation Treatment Facility)
5	RWSF (Radioactive Waste Storage Facility)
6	AFSB (Advanced Fuel Science Building)

2. Methods of evaluation for physical inventory

Facilities are 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 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 2. Based on the input data as shown in Table 2, the volume of the space was calculated, and the weight of the material constituting the space was calculated using the material density data.

Table 2. 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. 2D and 3D modeling of 6 nuclear facilities are carried out by MCNP. In this paper, only the process of calculating the concrete quantities for PIEF is shown, and the results are described for all 6 facilities. Typically, figure 1 shows the 2D modeling result of PIEF. 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 ordinary concrete and heavy concrete by volume.

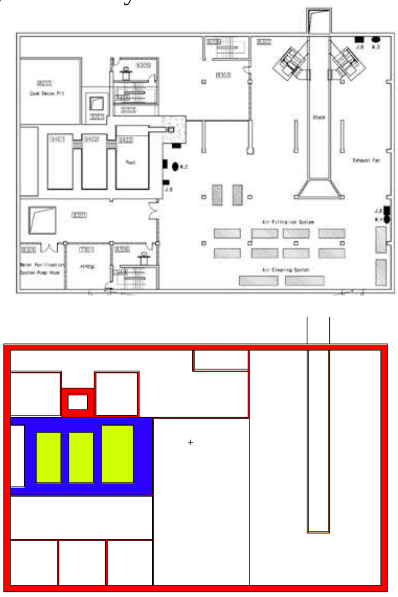

Fig. 1. Underground 1 floor drawings and 2D graphic result of PIEF

MCNP results were used to evaluate the inventory of building. In the case of PIEF, ordinary concretes are 13,156ton (5,720 m^3 x 2.3 ton/m^3), heavy concretes are 3,360ton (973 m^3 x 3.45 ton/m^3), doors (Fe) are 14.1 ton (18.05 m^3 x 7.8 ton/m^3 x 1/10), others (window) include about 3ton (1.421 m^3 x 2.32 ton/m^3).

Also, to estimate the radioactive wastes, the radioactive concrete wastes were evaluated according to equation (1). The annual report of KAERI was used to estimate the amount of radioactive wastes. The building waste consists of concrete waste, metal doors and equipment wastes. In order to estimate radioactive concrete wastes 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. Depth of contamination is derived from decommissioning experience of domestic research reactor (KRR-1&2). Based on these assumptions, it is calculated according to Equations (1), where Σ is the sum of each compartment and all the facilities surveyed.

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

As a result, table 3 shows the physical inventory and predicted waste of concrete for 6 facilities. The table 3 shows that there is not much difference between the physical inventory of concrete and the predicted amount of waste.

Table 3. Physical inventory and predicted waste quantity of concrete

Facility name	Physical inventory of concrete (Ton)	Predicted concrete waste quantities (Ton)	
		General	Radioactive
PIEF	16,513.8	15,757.1	132.9
		15,890.0	
RWTF	8,391.9	8,207.4	118.8
		8,326.2	
SWTF	6,263.3	6,255.9	19.1
		6,275.0	
NETF	2,386.1	5,376.5	21.3
		5,397.8	
RWSF	17,529.1	17,453.2	15.9
		17,469.1	
AFSB	7,699.2	6,009.4	52.1
		6,061.5	

4. Conclusion

In this study, the decommissioning concrete waste of physical and radiological inventory was evaluated by 3D modeling using MCNP code for 6 facilities in KAERI.

In the future, we plan to study on the evaluation of physical inventory for 6 nuclear facilities and then make them into computer tools. 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.

The physical results of 6 facilities calculated from this study can be used to evaluate the decommissioning strategy, worker exposure assessment, and decommissioning cost. 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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