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Development of a Methodology for Evaluating the Waste Amount of Activation Components in Pressurized Heavy Water Reactor

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1. Introduction

Wolsong unit 1, the first PHWR (Pressurized Heavy Water Reactor) in Korea, was permanent shut down in 2019. Wolsong unit 1 is the first PHWR in the world to adopt immediate decommissioning, and unlike PWRs (Pressurized Water Reactor), there is a lack of experience in overseas decommissioning and related research. However, in Korea, according to the Nuclear Safety Act, the FDP (Final Decommissioning Plan) must be submitted within 5 years of permanent shutdown.

During decommissioning, a large amount of radioactive waste is generated, of which activation components are expected to account for the highest radioactive level and a large volume. In addition, the amount of activation component affects the cost estimation, safety assessment, and radiation protection.

Therefore, this study developed a methodology for evaluating the waste amount of activation components in PHWR.

2. Methods and Results

The waste amount of activation components in PHWR can be evaluated in the order of selection of representative core, calculation of the neutron flux in components, calculation of the activation inventory in component, classification radioactive waste by level.

2.1 Selection of Representative Core

In order to apply a core model that is close to reality in the activation assessment, the calculation results by channel and bundle were analyzed with WIMS and RFSP (Reactor Fueling Simulation Program), a computer code for modeling the nuclear physics characteristics of PHWR. Fig. 1 shows nuclear physics characteristics of PHWR. The average power distribution by bundle for the entire period of the equilibrium core was determined with the representative core model.

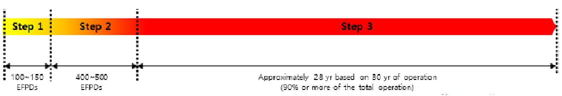

Fig. 1. Nuclear Physics characteristic of PHWR

Figure 2 shows the power distribution by bundle averaged over the period before the equilibrium core. This was selected as the representative core.

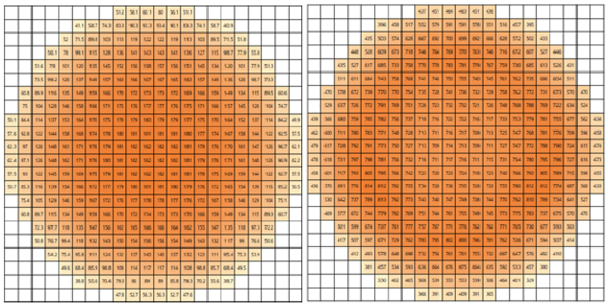
Fig. 2. Power distribution by bundle of representative core of Wolsong unit 1(left: center, right: outermost)

2.2 Calculation of Neutron flux in Components

Neutron flux in components calculation was performed using MCNP computer code. To model the geometry of the activation components, we analyzed design data of Wolsong unit 1 and visited the site. The neutron flux calculation was conducted for Calandria, the structures surrounding Calandria, and the Vault. Figure 2 shows Wolsong unit 1 as modeled by the computer code.

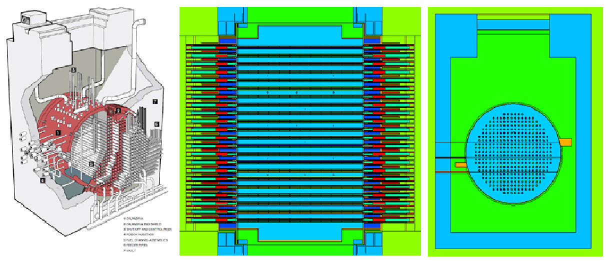
Fig. 3. Perspective drawing and computer model for calandria of Wolsong unit 1

2.3 Calculation of Activation Inventory in component

Activation inventory in components calculation was performed using ORIGEN-S computer code. The neutron flux and energy spectrum for each component calculated from the MCNP were used as input to the ORIGEN-S computer code. In addition, the material composition and the operating history of the Wolsong unit 1 core were input to calculate the activation inventory for each component.

2.4 Classification Radioactive Waste by Level

Table 1 shows the classification of radioactive waste levels presented in Nuclear Safety and Security Commission (NSSC) Notice 2020-6 "Regulation on the Criteria for the Classification and Clearance of Radioactive Wastes". According to these criteria, the radioactive waste level was evaluated for each activation component area.

After determining the radioactive waste level for each evaluation area, the amount of decommissioning waste was calculated by considering the mass of activation component of Wolsong unit 1.

Table I: Radioactive waste level classification

Level	Description
Intermediate Level Waste (ILW)	Radioactive wastes whose activity concentration is greater than or equal to the radionuclide-specific concentration provided in Attached Table 2 (Limit on radioactivity concentration of low-level radioactive wastes) among intermediate- and low-level radioactive wastes.
Low Level Waste (LLW)	Radioactive wastes whose activity concentration is more than 100 times the allowable clearance concentration and less than the radionuclide-specific concentration provided in Attached Table 2 (Limit on radioactivity concentration of low-level radioactive wastes) among intermediate- and low-level radioactive wastes.
Very Low Level Waste (VLLW)	Radioactive waste whose activity concentration is greater than or equal to the allowable clearance concentration and less than 100 times the allowable clearance concentration among intermediate- and low-level radioactive wastes.

3. Conclusions

In this study, a methodology for evaluating the waste amount of activation components in PHWR was developed. The waste amount of activation components in PHWR can be evaluated in the order of selection of representative core, calculation of the neutron flux in components, calculation of the activation inventory in component, classification radioactive waste by level. The results of this study can be used as a basis for radiation source characterization, cost estimation, and worker exposure dose assessment.

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