Segmentation and Packaging Plan for the Reactor Pressure Vessel

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1. Introduction

One of the most challenging tasks during plant decommissioning is the removal of highly radioactive internal components from the reactor pressure vessel (RPV) in the Kori unit 1. It is also expected to belong to the most difficult activities, because these must be segmented underwater due to the severe radiological conditions of the RPV internals [1]. In order to support this activity, the systems with cleaning of the water in the reactor cavity need to remain operational. It is therefore recommended that the reactor internals are removed as early as possible in the plant dismantling sequence, so that these water systems and their associated support systems can be released for decommissioning. This minimizes the costs of maintaining these systems in operation after permanent plant shutdown.

Moreover, after spent fuel, reactor internals constitute the next significant contributor to the radiological inventory of the decommissioned NPP. Therefore, the spent fuel removal and the early removal of the reactor internals significantly reduce the total site radiological hazard.

2. Segmentation and Packaging Plan

2.1 General Procedures to Develop the Plan

The segmentation and packaging plan is necessary to define in detail the sequential steps required to segment, separate, and package each individual component of RPV, based on an activation analysis and component characterization study. The plan is to describe the strategy for dismantling the components so that they can be disposed of in the most cost effective manner which can be governed by many factors such as waste container selection, disposal costs, transportation requirements, etc. [1]. The plan is prepared early in the planning phase before the dismantling activity considering the following sequences and processes [2],

- Collection of various types of design and operating data of the NPP
- Development of a 3D model of the reactor based on the collected data for the comprehensive understanding of the reactor
- Activation analysis of the reactor vessel and internals to define waste characterization and classification of the reactor components
- Evaluation of disposal options depending on waste characterization and the waste acceptance criteria
- Conceptual tooling development based on the activation analysis, waste characterization, and disposal option.
- Segmentation and packaging plan contains optimization packaging efficiency while considering segmentation schedule. And the plan defines type and quantity of waste containers and defines location and number of cuts per waste container

Based on the dismantling experience of the RPV internals, however, actual developing process of the segmentation and packaging plan is usually to start considering the end of the process such as handling of the containers, the waste acceptance criteria, what type and size of containers are available for the disposal options [1].

2.2. Disposal Requirements

In 2013, radioactive waste classification system in Korea was revised reflecting the international standard recommended by International Atomic Energy Agency (IAEA) [3], and specifies Low and Intermediate Level Waste (LILW) further into the Intermediate Level Waste (ILW), Low Level Waste (LLW) and Very Low Level Waste (VLLW) depending on its specific radioactivity [4].

The only disposal option currently available in Korea is the Gyeongju Centralized LILW Disposal Facility of cavern type repository. This repository is

designed to accept Very Low Level Waste (VLLW), Low Level Waste (LLW) and Allowable Intermediate Level Waste (AILW)*, in accordance with the corresponding Waste Acceptance Criteria (WAC), issued by KORAD as owner and operator of the facility.

Per the WAC for Gyeongju, the radioactive waste may be classified as VLLW, LLW or AILW. These classifications are based on the content of both long- and short-lived radionuclides in accordance with National Notice [4]. According to the WAC, the VLLW, LLW and AILW require immobilization and encapsulation inside the packages.

2.3 Waste Disposal Packages

In accordance with the segmentation and packaging strategy Non-AILW is stored in the specially designed canisters (SDCs), which are then placed into a temporary storage building or in an ISFSI [4]. The customer will supply all waste packages for the segmentation activity in compliance with appropriate KORAD WAC.

Until now waste containers are classified with steel drums, concrete containers, HIC, and polyethylene containers in Gyeongju. The steel drums are classified with 200L and 320L drums, and the concrete containers are classified with circular concrete containers and rectangular concrete containers [5]. LILWs packed in 200L drums are disposed of in a 16-pack concrete disposal container. The extra compressed 200L drums are packed again in 320L drums. The nine 320L drums are disposed of in a 9-pack concrete disposal container. The physical characteristics of the disposal container for the 200L drums and 320L drums are described in Table 4. The other concrete containers are disposed as itself in the repository.

2.4 Selection of a Cutting Technology

Segmentation of the RPV internals can be performed using thermal and mechanical cutting techniques and the best technique chosen will depend on the application and item to be cut.

Selection of the proper cutting technology in Kori unit 1, however, will be made considering the following factors in detail based on the past experience,

- Occupational safety and optimization for radiation protection
- Secondary waste minimization
- Process safety and simple operation
- Reliability and maintainability
- Cutting capacity

3. Conclusion

It is important to well prepare the dismantling of a RPV internals in advance. A detailed study of the optimum dismantling scenario must be done upfront, considering the available plant systems and infrastructure.

3D models help complete these tasks as well as for determining the logistics of component placement and movement in the reactor cavity. With optimized planning and predictable results, these complicated tasks can be performed while maintaining occupational exposure and controlling project costs.

The amount of cutting should be optimized with respect to the number of cuts and the size of the final waste packages. The cutting plan should minimize the number of cuts, produce waste pieces that can be easily packaged, and minimize the final waste volume. Segmentation should begin with the least irradiated components in order to gain experience with the tooling before applying it to highly radioactive components, where tooling failure could significantly increase personnel exposure.

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