Specification Requirements and Considerations Based on Operation Experiences of Spent Fuel Pool Island

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1. Introduction

The concept of spent fuel pool island (SFPI) is defined as a design change for the isolation of spent fuel pool cooling and cleanup system for efficient and easy decommissioning of structures, systems, and components during decommissioning and decontamination (D&D) period of nuclear power plant. The SFPI is one of the most important preparation activities for D&D during transition period in order to ensure safe and efficient spent fuel management. It is necessary for discussion of SFPI because Korea currently has uncertainty of spent fuel management strategy. In addition, the SFPI is one of the best alternatives to solve the problem due to the absence of intermediate spent fuel storage facility in Korea. In this paper, the specification requirement and considerations is reviewed based on operation experiences of SFPI in other D&D cases, and the applicable specification requirement of SFPI in Korea is derived through the review.

2. Specification Requirement and Considerations

2.1 Predominant Radionuclide Constituents

The predominant radionuclide constituents are the values of radionuclides created according to long term storage of spent fuel in the spent fuel pool. In other words, the values provided are representative of a pool configured for long-term fuel storage. Significant disturbances in the pool, such as movement of fuel elements or pool cleanup operations, would be expected to elevate the activity. While there is a consistency from plant-to-plant with regard to the types of soluble radionuclides, there may be more variation in radionuclide concentrations found in crud layers or particulates on the fuel pool floor. Notable would be the appearance of transuranics correlated to damaged fuel.

Most plants do not have an explicit specification regarding pool water radionuclide concentration. Whereas Homboldt, Trojan, LaCrosse nuclear power plant have the specification requirement, the value is reported about 2.5E3μCi/ml. The allowable activity is often defined by personnel radiological protection practices and system purification capability. Plant response indicated that plant criteria for pool water radionuclide removal after permanent shutdown did not change from those applied during plant operation. As a potentially unique practice, the Yankee Rowe plant evaluates Cs-137 generation rate twice yearly as a method of identifying cladding degradation.

2.2 Non-radiological Constituents

Most plant have technical specifications regarding non-radiological constituents in the fuel pool water. Interestingly, many of these specifications were added only after final shutdown (e.g., Rancho Seco). Control of fluorides and chlorides are most common. Boron requirements have been removed or reduced in several plants after demonstration that it is not needed for criticality control (e.g., through use of boral racks). Purification systems generally do not actively remove the boron, but its concentration may gradually decrease (e.g., through system leakage).

On case of Connecticut Yankee nuclear power plant, the requirement is to inject boron in the pool when the anion increases more than 10 times or silicon dioxide increases more than 30 times. SiO_2 factor need to be monitored periodically as indicate of the boral racks degradation

2.3 Resin Change-out Frequency and Basis

Most plants that modified the original system or installed a new cleanup system for post shutdown activities are using an ion-exchange vessel of about

30 ft^3 volume. Mixed-bed demineralizers are common. Criteria for vessel change-out include change in differential pressure(dp), change in flow(df), ALARA, and control of waste form classification. Change-out frequency is dependent on fuel pool operational activities. In a quiet pool, resin change-out frequencies of well over a year were often reported. Conversely, Trojan reported the need to change resin every few days after the use of a cesium selective removal resin (in preparation for cask loading) resulted in a higher proportion of soluble cobalt in the pool. As a result reviewing resin change-out frequency based on the SFPI operation experiences, the resin is needed to change out once per every 18 or 24 month in order to satisfy the ALARA requirement, and the reduction of flow rate in demineralizer determine replacement intervals of resin.

2.4 Spent Fuel Pool Area Dose Rates

In comparison to plant operation, most plants reported that spent fuel pool general area dose rates are unchanged and reduced. Dose rates in the area of new components (e.g, demineralizer) may require additional shielding for the radiological dose rate management. Over time, pool cleanup activities and radionuclide decay tend to decrease the importance of the pool water as a source of dose during fuel storage periods. Accordingly, it is not necessary to establish the limitation value of a radiological dose rate as a requirement. Therefore the setting of radiological dose rate in general area is less than 1mR/hr as the administration limit which is not mandatory.

3. Applicable Specification Requirement

This chapter derives applicable requirement of SFPI in Korea based on specification requirement and considerations reviewed above. The derived specification requirement for SFPI is conservative value and contents based on other cases. This value and contents are meaningful specification requirement as a reference. In addition, these are changeable according to the inherent characteristic of nuclear power plant, public acceptance, etc. The specification requirements in details are shown in Table 1.

Table 1. Specification requirement for SFPI

Specification	Contents
Radionuclide Constituents	H-3(4E-4 μCi/ml), Co-60(3E-5 μCi/ml), Cs-134(1E-7 μCi/ml) Cs-137(1E-5 μCi/ml) Cs-137 generation rate measured 2x per year to monitor cladding integrity
Non-radionuclide Constituents	Boron>2000 ppm, Fluoride<150 ppb Chloride<150 ppb, Sodium<1000 ppb Suspended Solids<1000 ppb SiO2 monitored as indicator of The boral racks degradation
Resin Change-out Frequency and Basis	Demineralizer flow reduction governs the change-out frequency; ALARA practices previously caused change-out on 18-24 month interval.
SFP Area Dose Rates	No significant change from operation (< 1 mR/hr in general area)

4. Conclusions

This paper reviewed the specification requirements through operation experiences of SFPI in other cases and derived applicable reference requirements for SFPI in Korea. The SFPI is an option that can be considered in order to manage spent fuel during transition period and reduce decommissioning cost in the implementation of D&D project in near future. If SFPI concept is adopted as spent fuel management plan after NPP permanent shutdown in the future, the practical requirements for SFPI can be derived based on specification requirement and considerations described in this paper.

REFERENCES

[1] DOE G 430.1-5, “Transition Implementation Guide”, U.S. Department of Energy, 2011.

[2] EPRI Technical Report, “Spent Fuel Pool Cooling and Cleanup System – Experience at Decommissioning Plants”, 2002.