Spent Fuel Pool Island System Configuration Concept – Comparison of German and the US Regulatory Standards

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1. Introduction

The spent fuel management after nuclear power plant (NPP) permanent shutdown is one of the key factors to determine the NPP decommissioning strategy and related system design. But there are many uncertainties regarding the spent fuel management in Korea. In addition, the decommissioning regulatory standards for spent fuel pool island (SFPI) in case of Germany and the US should be reviewed in more detail, which are the representative international regulatory standards [1][2]. In this paper, the SFPI system configuration concept is reviewed with comparison of the regulatory standards of Germany and the US, and more efficient and regulatory adaptable design concept is derived.

2. Regulatory Standards of Germany and the US

2.1 German Regulatory Standards for SFPI

In Germany, the operating license is valid until decommissioning license permission after the NPP permanent shutdown. Accordingly any system modification/installation/removal/operation during "Decommissioning Transition Period" (permanent shutdown ~ decommissioning license permission) should be complied with the regulatory framework applied during the normal operational phase.

2.2 The US Regulatory Standards for SFPI

In case of commercial NPP in the US, the submission only of DSAR (Defueled Safety Analysis Report) and PSDAR (Post Shutdown Decommissioning Activities Report) after the permanent shutdown is necessary to start NPP decommissioning works. Therefore it is possible to perform system modification/installation/removal/ operation with just system function review during decommissioning phase, regardless of operating license compliance [2].

3. SFPI System Configuration Concept

3.1 Spent Fuel Pool Cooling System(SFPCS) Concept

During the operational phase, SFPCS shall consist of two(2) safety-related class trains to comply with operating license. Therefore, in Germany, SFPCS shall consist of two(2) safety-related class trains likewise.

However, in the US, SFPCS may consist of one(1) non-safety-related train if SFPCS with only one(1) train can achieve spent fuel pool cooling. This design concept has been already applied to several NPP decommissioning projects in the US. But it should perform more detailed analysis whether SFPCS can ensure spent fuel pool safety even if SFPCS loses its cooling function because of a certain accident.

3.2 Spent Fuel Pool Cleanup System Concept

The spent fuel pool cleanup system is designed to keep the dose rate at water surface below 0.025 mSv/hr by purifying spent fuel pool water. This allows the workers to access the spent fuel pool during fuel handling works.

At the operational phase, spent fuel pool cleanup system shall consist of two(2) non-safety-related trains. But only in the early stages of refueling phase, both two(2) trains are operated at the same time to quickly purify a lot of refueling pool water. Spent fuel pool cleanup system can consist of one(1) non-safety-related class train because after NPP permanent shutdown spent fuel refueling work isn't necessary any more. In addition, SRP (Standard Review Plan), which is used as a design guideline for

spent fuel pool, doesn't require two(2) trains composition.[3]

In other words, spent fuel pool cleanup system can consist of one(1) non-safety-related class train even under operating license. Thus, in both German and the US, it is possible to design only one(1) non-safety-related class train if system can achieve the own system goal.

3.3 Make-up Water System (Seismic Category I)

Under operating license, seismic category I make-up water shall be provided to the spent fuel pool as specified in SRP 9.1.3[3]. The goal of make-up water is to make up spent fuel pool water evaporated by the heat load of spent fuel when loss of SFPCS function happens. Therefore make-up volume for make-up water system (seismic category I) should be calculated considering spent fuel pool volume, accident recovery time, heating time and evaporating time of spent fuel pool water.

As the heat load of spent fuel decreases after NPP permanent shutdown, evaporation of spent fuel pool water can be prevented without specific seismic category I make-up source. However, in Germany, a specific seismic category I make-up water source shall be provided as well as NPP operational phase.

In contrast, in the US, if cooling requirement can be achieved without a specific seismic category I make-up source, make-up water system (seismic category I) is not required.

3.4 Make-up Water System (Other)

At the operational phase, make-up water system (other) consists of de-mineralized water, boric acid water, and emergency external makeup water. These three(3) water sources are essential for the operation of spent fuel pool. Therefore make-up water system (other) is provided in both Germany and the US.

3.5 Heat Exchanger Cooling Water System (HECWS)

HECWS supplies cooling water to the spent fuel pool heat exchanger. In both Germany and the US, HECWS is essential to cool spent fuel pool water.

In Germany, since SFPCS has two(2) safety-related class trains, HECWS shall have two(2) safety-related class trains as well. In the US, however, if SFPCS consists of only one(1) non-safety-related class train of non-safety-related class, HECWS can be composed of one(1) non-safety-related class train as well.

3.6 Emergency Diesel Generator System (EDGS)

EDGS supplies alternative power to SFPI systems, such as pumps, in loss of on-site power. EDGS is composed of two(2) Class 1E emergency diesel generators at the NPP operational phase.

In Germany, because EGDS shall supply emergency power to two(2) trains of SFPCS, EGDS shall consist of two(2) Class 1E emergency diesel generators, like the existing EDGS

In the US, Class 1E emergency diesel generator is not necessary if cooling requirements of spent fuel pool can be met, even if both on-site power and off-site power are lost. However, in the case of SONGS (San Onofre Nuclear Generating Station) and Zorita NPP, with small capacity Non-Class 1E emergency diesel generator was installed for decommissioning phase and an emergency plan was prepared for off-site power loss accidents. So these examples of SONGS and Zorita can be considered for KORI unit 1 decommissioning project.

4. Conclusions

This paper compares and reviews SFPI system configuration concept according to Germany and the US regulatory standards. If SFPI concept is adopted as spent fuel management plan after NPP permanent shutdown in the future, the practical design concept can be derived based on the assumptions described in this paper.

REFERENCES

[1] "High Level Radioactive Waste Management Plan", MOTIE, May 2016.

[2] DOE G 430.1-5, "Transition Implementation Guide", U.S. Department of Energy, 2011.

[3] SRP 9.1.3 "Spent Fuel Pool Cooling and Cleanup System", U.S. Nuclear Regulatory Commission.