

Decommissioning Design of Spent Fuel Pool Cooling and Cleanup System

Tae Hwa Lee*, Young Hun Shin and Kwang Soon Choi
Korea Electric Power Corporation Engineering & Construction (KEPCO E&C)
269, Hyeoksin-ro, Gimcheon-si, Gyeongsangbuk-do, Republic of Korea, 39660
*Corresponding author: etaewha@kepc-eenc.com

***Keywords:** Decommissioning, Nuclear, Spent Fuel Pool, Spent Fuel Pool Cooling and Cleanup System (SFPCCS)

1. Introduction

In Korea, regarding the decommissioning of nuclear facilities, a partial revision of the Nuclear Safety Act was promulgated on January 20, 2015. Subsequently, revisions were made to the Enforcement Decree and Enforcement Rules of the Nuclear Safety Act, the "Regulation on Technical Standards for Reactor Facilities, etc." by the Nuclear Safety Commission, and the "Guidelines for Preparing Decommissioning Plans for Nuclear Facilities" were also published.

In December 2015, the safety review guidelines for light-water reactors (6th edition) were revised. Articles 12.3 to 12.4 specify, based on Article 85-6 of the "Regulation on Technical Standards for Reactor Facilities," that "within the scope feasible during operation, the design must minimize contamination of the facility and environment and reduce radioactive waste generation during decommissioning." In the review procedures, item III-7 directly refers to RG 4.21, stating that "reviewers shall evaluate the design characteristics described in the safety analysis report that aim to minimize contamination and radioactive waste generation during decommissioning according to RG 4.21."

The Spent Fuel Pool Cooling and Cleanup System (SFPCCS) must continue to cool and purify the pool water using the original SFPCCS facilities if the spent fuel stored in the pool can not be transferred to interim or permanent storage in time after plant shutdown. This extended operation of unnecessary systems and equipment leads to high costs and potential complications during the decommissioning process.

In the U.S., an independent SFPCCS is installed and operated until the spent fuel is moved to interim or permanent storage. This paper presents a conceptual design review of such an independent SFPCCS considering decommissioning.

2. Overseas Development Status

2.1 Maine Yankee Nuclear Power Plant (US)

The Maine Yankee nuclear power plant, located in Wiscasset, Maine, USA, was an 860 MWe unit that began commercial operation in 1973. Decommissioning was decided in 1997, and decommissioning was completed in 2005. Operation of an Independent Spent

Fuel Storage Installation (ISFSI) began in 1998, and spent fuel was stored and managed on site until completion of the interim storage facility in 2002.

An SFP completely isolated from the plant's existing systems, structures, and components (SSCs) was established, and new systems were installed for cooling and cleanup, monitoring (SFP water temperature, system operating parameters, radiation levels, fire watch, etc.), control, and power supply (including a diesel generator). An above-ground, independent interim storage facility employing dry storage was adopted, using casks made of steel and concrete. After a holding period in the SFP, cooled fuel was sealed in casks and transferred to the dry storage facility for storage.

At Maine Yankee, the configuration comprised three stages: the SFP cooling system, the intermediate cooling water circulation system, and the air-cooled ultimate heat sink system. Even if cooling water leaked from the SFP heat exchanger, the intermediate cooling water loop provided a secondary barrier.



Fig. 1. Independent Spent Fuel Storage Installation (ISFSI)

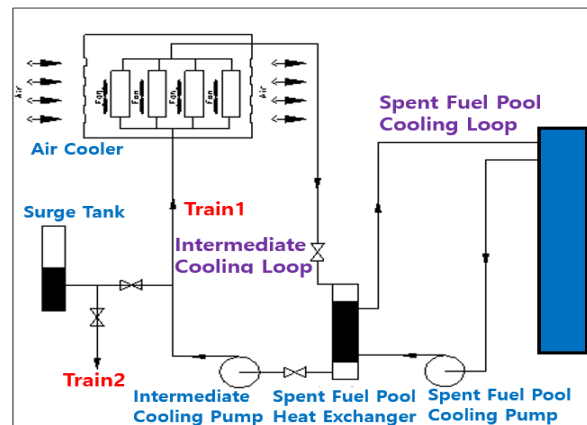


Fig. 2. Concept of Independent SFP Cooling System at Trojan

Two pumps will be newly installed in the intermediate cooling water circulation system. The circulation pumps will be placed adjacent to the existing SFP cooling equipment and near the fuel-handling area, i.e., in the New Fuel Inspection Area of the auxiliary building. As a non-radioactive system, even if leakage occurs from the SFP heat exchanger, the radioactivity concentration in the intermediate cooling water is expected to be very low.

Hence, shielding walls to isolate the two pumps are considered unnecessary.

The intermediate cooling water circulation system for the decommissioning phase will have two trains and share a single surge tank. In large plants, the CCW system typically has four trains, with each train's surge tank located in each quadrant of the auxiliary building. Accordingly, the surge tank for the decommissioning intermediate loop will reuse a surge tank from the large plant.

The ultimate heat sink for the SFP cooling system in decommissioning will be air-cooling. According to information obtained from vendors, the air-cooled heat exchanger is an integrated air-cooled package that requires unimpeded airflow for fan operation. Therefore, installing the air-cooled package inside an auxiliary-building compartment is not feasible. The air-cooled heat exchanger should be installed on the auxiliary-building roof or in an outdoor area adjacent to the auxiliary building.

4. Conclusions

This study reviewed configuration and layout options for an independent SFP cooling system for use during decommissioning. The concept is to continue using the existing two trains of SFP pumps and heat exchangers while isolating the CCW supply piping on the primary side and adding an intermediate cooling water circulation system together with an air-cooled ultimate heat sink. The SFP cleanup system is assumed to remain in service during decommissioning, as large-capacity cleanup may be required due to fuel transfer and related activities. For newly installed equipment to independently operate the SFP cooling system during decommissioning, placement is considered feasible by utilizing removed equipment compartments near the auxiliary-building fuel-handling area or compartments unused in the decommissioning phase.

Because this review concerns the design and layout of an SFP cooling system applicable during decommissioning, the latest regulations and requirements at the expected time of decommissioning must be applied. The review also assumes that no domestic interim storage or permanent disposal facility for spent fuel has been established.

Considering these uncertainties, additional design reviews are needed for the independent SFP cooling system to be applied during decommissioning, including penetrations through general equipment layouts in the auxiliary building, designs for removable walls, and designs for supporting systems.

REFERENCES

[1] Spent Fuel Pool Cooling and Cleanup Systems—Experience at Decommissioning Plants, EPRI, May 2002.

[2] Domestic Application Review of Independent Spent Fuel Pool at NPP Decommissioning, April 2015.

[3] Spent Fuel Pool Cooling and Cleanup During Decommissioning—Experience at Trojan Nuclear Power Plant, EPRI, March 1999.

[4] Regulatory Guide 4.21, Minimization of Contamination and Radioactive Waste Generation.

[5] Regulatory Guide 1.184, Decommissioning of Nuclear Power Reactors (Revision 1), U.S. NRC, 2013.

[6] Regulation on the Classification of Radioactive Waste and Criteria for Clearance, NSSC.

[7] Act on the Safety Control of Nuclear Facilities and Radiological Protection.

[8] Enforcement Decree of the Act on the Safety Control of Nuclear Facilities and Radiological Protection.

[9] Enforcement Rules of the Act on the Safety Control of Nuclear Facilities and Radiological Protection.

[10] Regulation on Technical Standards for Reactor Facilities, etc., NSSC.

[11] Regulation on the Preparation of Decommissioning Plans for Nuclear Facilities, etc., NSSC.