

The Improvement of Layup Methods for Primary System & Secondary System due to Long-Term Shutdown of K Unit 2

Byung-hoon Kim^{a*}, Seong-jib Choo^a, Soon-woo Kwon^a, Hyuk-chul Kwon^b

^a Nuclear Power Plant 1, Kori Nuclear Power Site, Korea Hydro and Nuclear Power Co., Ltd

^b Central Research Institute, Korea Hydro and Nuclear Power Co., Ltd

*Corresponding author: benign.kim@khnp.co.kr

***Keywords :** Layup, Stress Corrosion Crack (SCC), Secondary System Corrosion, Monitoring Specimen

1. Introduction

K Unit 2 was shutdown on April 8, 2023, after 40 years of commercial operation. Accordingly, K Unit 2 is preparing to improve facilities for license renewal and obtain approval from regulatory agencies. Since facility improvement and licensing approval take a long time, procedures for maintaining the integrity of the primary system and secondary system components of the nuclear power plant need to be prepared. In general, if it was a normal overhaul, layup is managed according to the operation procedure. Layup treatment and evaluation for primary system and secondary systems and facilities was prepared by referring to the operation procedures and EPRI guidelines [1]. This evaluation method is aim to verify the integrity of systems and components before re-start plant after long-term shutdown.

2. Methods and Results

In general, NPPs adapted wet-layup and dry-layup for system and components during shutdown to prevent the corrosion or malfunction. Wet-layup uses chemical contained water to maintain anti-corrosive conditions, and dry-layup uses dehumidified or dried air to maintains relative humidity below 40%.

DR = Drained

CAD = Compressed Air Drying

DAD = Dehumidified Air Drying

For the steam generator, dry-layup on the primary side, wet-layup on the secondary side with nitrogen blanket were applied.

2.1 Primary System

For the primary system, wet-layup was applied to the reactor coolant, CVCS, RWST, and safety injection. And dry-layup was applied to pressurizer. Generally, EPRI guidelines and the existing plant applied the primary system dry-layup, but our plant improved to manage SCC factors by applying the wet-layup method of the primary system. The improvement method is operating residual heat removal pump and charging pump to prevent corrosion caused by boric acid deposition, and effect will be verified through performing purification and water analysis. In case of systems applied wet-layup such as reactor coolant, safety injection, RWST, etc., main impurities like fluorine (F⁻), Chlorine (Cl⁻) and Sulfuric ion (SO₄²⁻) will be monitored and controlled more strict than normal overhaul duration. [2].

2.2 Secondary System

For the secondary system, the plan was established and applied by referring to the EPRI guidelines based on the plant procedure. Previously, Many NPPs didn't have detail evaluation method for secondary system about layup. We collaborated with the Central Research Institute (CRI) and the Korea Atomic Energy Research Institute (KAERI) to evaluate the corrosion prevention effect and verify the result of layup. The assessment strategy is to evaluate corrosion through a method of collecting an oxide film on the metal surface and monitoring specimens.

The monitoring specimens are same material as the secondary system. And total three types of specimens, including the oxidized specimen, were loaded into the 5 different locations of the secondary system.

Table I: K Unit 2 Layup Plan

System	Wet-Layup	Dry-Layup		
		DR	CAD	DAD
Primary	Reactor	●		
	PZR		●	
	CVCS	●	●	
	RWST	●		
	Safety Injection	●		
Secondary	Steam Generator	● (N ₂)		
	Deaerator			●
	FW/CD		●	● (TBN)
	MS		●	
	HTR		●	
	Steam Converter	●		
Stator Cooling			●	

2.3 Monitoring Specimen

The Monitoring specimens consist of SA106Gr.B, SA516Gr.70, SA335P22. And they were loaded into Condenser, HTR #1/2, HTR #3, Deaerator, HTR #6 in July 2023. Some monitoring specimens will be withdrawn in December 2023, and the remaining monitoring specimens will be withdrawn in December 2024 to evaluate the weight loss and surface condition. And the properties and components of the oxides film produced on the surface will be analyzed by SEM, XRD, etc.

REFERENCES

- [1] EPRI, Sourcebook for Plant Layup and Equipment Preservation, Revision 1 (NP-5106), 1992.
- [2] EPRI, Pressurized Water Reactor Primary Water Chemistry Guidelines: Volume 1 & 2, Revision 7 (3002000505), 2014.

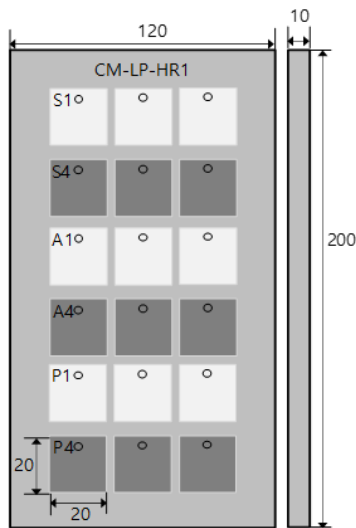


Fig. 1. Monitoring Specimen Configuration

Table II: Loaded Status of Monitoring Specimens

Condenser	HTR #1/2	HTR #3	Deaerator	HTR #6

3. Conclusions

During the facility improvement period for license renewal, K Unit 2 execute proper layup of the primary system and secondary system to prevents SCC of components and pipes. And the process of oxidation and protective film formation of secondary system in the plant can be tracked through the monitoring specimens. This result will suggest supplementary directions the layup process of K Unit 2. It also can be used as a reference for domestic power plants that are scheduled for a long-term shutdown in the future.