A Review of Secondary System Water Chemistry Behavior during Flexible Reactor Operation in PWRs

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1. Introduction

Most nuclear power plants(NPPs) in Korea maintain full power operation throughout the entire period. However, flexible operation (load-following) is being implemented during certain periods in response to changes in power demand. In this study, we analyzed the behavior of the secondary system water chemistry according to power variations and reviewed the changes in water quality analysis of the main feedwater system and steam generator (SG) blowdown to evaluate the impact on safety.

2. Secondary System Water Chemistry Gap Analysis

A gap analysis between normal operation and flexible operation was performed by analyzing the water chemistry data of NPPs that have implemented flexible operation. For the feedwater system, control and diagnostic parameters were reviewed, and for the SG, impurity discharge behavior (hideout return) was examined.

2.1 Evaluation of Water Chemistry Behavior in the Feedwater System

The feedwater chemistry of the secondary system is managed to prevent degradation of steam generator performance and to ensure long-term material integrity. The control parameters include pH, dissolved oxygen, hydrazine, iron and copper. The pH of the feedwater system is determined by the concentrations of ethanolamine (ETA), hydrazine(N_2H_4), and ammonia(NH_3). During flexible operation, the feedwater flow decreases in proportion to reactor power, which can cause variations in chemical concentrations and pH. However, chemical concentrations are controlled by adjusting the chemical injection pump stroke. A review of plant water chemistry data confirmed that there were no significant changes in feedwater pH or chemical concentrations during flexible operation. Similarly, variations in dissolved oxygen, iron, and copper concentrations were not significant.

The diagnostic parameters that indicate feedwater chemistry status include total conductivity and cation conductivity, sodium ions, ETA, and NH_3. The results showed no significant changes in cation conductivity and pH due to power variations.

Table 1. Variation of Chemical Concentration according to Reaction Power

Plant	Power(%)	pH	ETA	N_2H_4(ppb)
A(25.3.30)	100→85.7	9.84→9.85	5.02→5.12	219→218
A(25.4.27)	100→82.0	9.84→9.83	5.08→5.12	211→202
B(25.3.23)	100→80.7	9.76→9.76	5.10→4.90	158→167
B(25.3.23)	100→81.0	9.75→9.75	4.70→4.50	171→185

2.2 Evaluation of Steam Generator Hideout Impurity Behavior

The main analysis parameters for SG hideout impurities include Na^+, Cl^-, K^+, SO_4^{2-}, Ca^{2+}, and $Mg^{2+.}$ During flexible operation, certain plants exhibited transient changes in sodium concentration, but these trends were not consistent across all sites. Therefore, the observed variations cannot be attributed solely to hideout return behavior. This is expected to be influenced by changes in chemical concentration and the status of ion exchange resins.

3. Conclusion

The behavior of secondary system water chemistry in the feedwater and steam generator systems was analyzed to assess the effect of flexible operation (100–80–100%) currently applied in domestic NPPs.

The results confirmed that chemical concentrations are being appropriately controlled despite decreased feedwater flow, indicating that flexible operation has a minimal impact on water chemistry stability. In effect, the variability of pH increases following flexible operation, which appears to be driven by changes in ammonia production resulting from the decomposition of ETA and hydrazine. The review of SG hideout impurities showed that impurity variations during flexible operation differed among power plants, indicating that further evaluation is required. In the future, the water chemistry impact on the primary and secondary systems due to expanded flexible operation power variations (100-50-100%) will be reviewed.

REFERENCES

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