Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22-23, 2025

Prediction of Water Chemistry for Amine Form Operation of Condensate Polisher in NPPs Using PCS program

Da-Seul Ham*, Hyuk-Chul Kwon, Seung-Ho Lee, Cho-Rong Kim, Yong-Sang Cho
KHNP Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, Korea,34101
*Corresponding author: dshahm09@khnp.co.kr

Keywords : amine form operation, condensate polishers, pH, iron oxide

1. Introduction

The primary material used in the secondary system of nuclear power plants is carbon steel, and the main corrosion mechanism is flow-accelerated corrosion (FAC) [1]. Oxide deposits generated due to FAC are carried into the steam generator during normal operation, where they accumulate and contribute to stress corrosion cracking (SCC) of tubes.

To minimize FAC, it is desirable to increase and maintain the secondary system pH to a level where carbon steel corrosion is minimized [2,3]. However, during pH elevation operation, there is a problem where the saturation point of the demineralizer is accelerated due to pH control agents such as ethanolamine (ETA). To address this issue, the amine form operation was applied to the condensate polisher(CPP). Amine form operation refers to a method in which one train of the condensate polisher (CPP) is saturated with amine to increase pH, while the other train operates to remove impurities.

Before applying this method to nuclear power plants, it was necessary to predict and understand water chemistry changes resulting from pH elevation and establish countermeasures based on the predictions. Therefore, this study utilized the Plant Chemistry Simulator (PCS) program developed by the Electric Power Research Institute (EPRI) to predict water quality changes.

2. Methods and Results

In order to predict the pH distribution and cation conductivity changes due to the increase in secondary system pH, a water quality prediction model was created based on operating conditions during operation of nuclear Power Plant, where actual amine form operation will be applied. In addition to ETA, ammonia (NH_3) generated as a thermal decomposition product of secondary system chemical agents also contributes to pH elevation. Therefore, the required ETA concentration to maintain the target pH was calculated considering the NH_3 concentration in the Feedwater, as shown in Table 1.

Table I: Estimated ETA concentration by Feedwater pH

Ammonia concentraion	Required ETA concentration	
	pH 9.8	pH 9.9
NH_3 300 ppb	① ETA 11.4 ppm	⑥ ETA 17.3 ppm
NH_3 500 ppb	② ETA 10.9 ppm	⑦ ETA 16.8 ppm
NH_3 1,000 ppb	③ ETA 9.7 ppm	⑧ ETA 15.6 ppm
NH_3 1,500 ppb	④ ETA 8.5 ppm	⑨ ETA 14.4 ppm
NH_3 2,000 ppb	⑤ ETA 7.3 ppm	⑩ ETA 13.2 ppm

2.1 Prediction of pH Changes

The predicted pH distribution changes in the secondary system are shown in Figure 1.

Based on the analysis of pH distribution changes using $pH_{25°C}$, a parameter measured and managed in the actual nuclear power plants, it was confirmed that the overall system $pH_{25°C}$ increased due to the pH rise compared to the previous Feedwater $pH_{25°C}$ of 9.7. Although the evaluation should be conducted alongside the actual measured corrosion amount, the PCS results predict that amine form operation will reduce system corrosion.

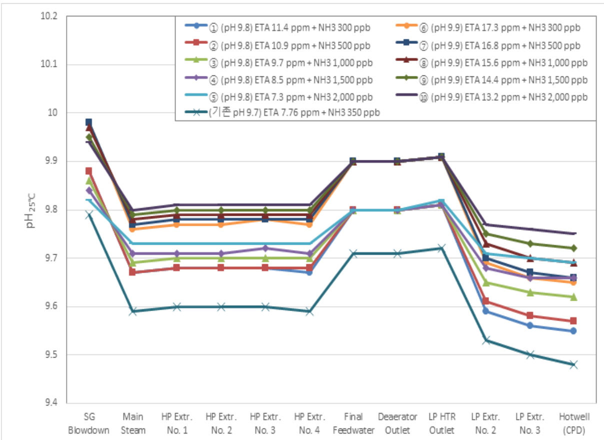

Fig. 1. Predicted changes in pH distribution in secondary system

2.2 Prediction of Cation Conductivity Changes

The PCS program prediction results for cation conductivity are shown in Figure 2 and table 2. It is predicted that cation conductivity will increase almost throughout the system as pH increases. During normal operation of nuclear power plants, cation conductivity is mainly affected by the concentration of organic acids (glycolic acid/acetic acid/formic acid) which are thermal decomposition products of ETA, the increase in cation conductivity was prominent under conditions where ETA concentration was high. Based on the prediction results, it was confirmed that when the feed water pH approaches 9.9 in the early stage of application of amine foam operation, cation conductivity value main steam and condensate pump outlet water may exceed the normal value.

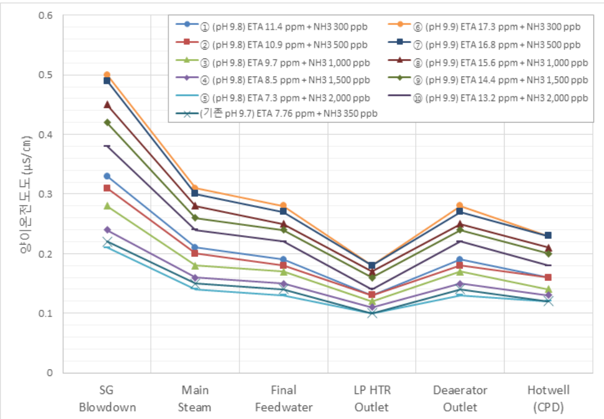

Fig. 2. Predicted changes in cation conductivity in secondary system

Table 3: Estimated ETA concentration by Feedwater pH

Feedwater pH	Results of cation conductivity prediction (uS/cm)			
	SG Blowdown	Main Steam	Feedwter	Hotwell
9.71	0.22	0.13	0.15	0.13
9.8	0.33	0.21	0.19	0.16
9.9	0.50	0.31	0.23	0.23
Normal Value	$\leq$ 1.0	$\leq$ 0.30	$\leq$ 0.20	$\leq$ 0.20

3. Conclusions

When the secondary system pH is increased, the overall ETA concentration in the system rises, leading to changes in water chemistry parameters, including pH distribution and cation conductivity. In this study, the EPRI PCS program was used to predict pH and cation conductivity changes in the secondary system due to increased feedwater pH. Since the overall pH of the secondary system is expected to rise, this change is anticipated to be beneficial for corrosion reduction. In the case of cation conductivity, an increase in ETA concentration may lead to a rise in thermal decomposition byproducts (organic acids), causing an overall increase in cation conductivity throughout the secondary system. In particular, some systems, such as the main steam system, may exceed management criteria, necessitating enhanced monitoring.

REFERENCES

[1] M. Caravaggio, "Guidelines for Control of Flow-Accelerated Corrosion in Fossil and Combined Cycle Plants", EPRI Report 3002011569, 2017

[2] Pressurized Water Reactor Secondary Water Chemistry Guidelines—Revision 8. EPRI, Palo Alto, CA: 2017. 3002010645.

[3] Multivariable Assessment of Flow Accelerated Corrosion and Steam Generator Fouling: Literature Review, EPRI, Palo Alto, CA: 2003. 1003619