

Breakthrough of Amine in Condensate Polishing Resin: A Method for High-pH Operation and Corrosion Reduction

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1. Introduction

In PWRs, flow-accelerated corrosion(FAC) of secondary system carbon steel produces corrosion products that accumulate in feedwater components and impair steam generator performance. To suppress corrosion, ethanolamine(ETA) is commonly injected to maintain feedwater pH within 9.7-10.0 at 25°C. However, a large fraction of ETA is removed in the condensate polishing plant(CPP), which reduces its effectiveness and increases resin regeneration frequency. To overcome these limitations, KHNP applied an amine breakthrough strategy by saturating high-purity ion exchange resins with amines during operation, thereby enhancing pH control and extending resin life.

2. Method

During amine saturation, impurities inherently present in the resin are released, producing “Blip” phenomena such as sodium ion breakthrough. To minimize this risk, high-purity resins with low residual sodium were employed. A pilot application was conducted at Kori Unit 3, where one mixed-bed demineralizers was saturated with amine and operated under standard conditions. However, during this trial, significant amounts of ammonium ions were generated from hydrazine decomposition, leading to uncontrolled increases in feedwater pH. Excessive pH rise showed the limit of direct amine breakthrough. Based on this operational experience, an additional measure was introduced when applying the method to OPR and APR plants. A dedicated cation demineralizer was operated in parallel with the amine-saturated line to remove excess ammonium ions and stabilize the pH. Approximately 600 m³/hr of the total 650 m³/hr condensate flow was passed through the amine-saturated line(1 cation + 1 mixed bed), while about 50 m³/hr was directed through the parallel cation bed. Flow distribution was controlled via outlet valves to ensure that condensate pH remained within the upper limit of the chemistry specification. This modified configuration successfully maintained pH stability and became the reference setup for subsequent applications, including the long-term demonstration at Hanul Unit 6.

3. Results and Discussion

At Hanul Unit 6, a 10-month trial confirmed the effectiveness of amine breakthrough operation. Feedwater pH increased from 9.77 to 9.87, and ion concentration decreased by 61%, from 3.1 to 1.2ppb. The resin regeneration cycle extended from once a week to once every two months, while chemical usage decreased from 52.7 tons to 7.3 tons, and wastewater generation was reduced by 85%. During the trial, cation conductivity increased from 0.22 to 0.6 $\mu\text{S}/\text{cm}$ as a result of organic acid formation from ETA decomposition. However, these organic acids are volatile and their impact on corrosion was negligible.[1] Importantly, the target feedwater pH of ≥ 9.8 was achieved with reduced chemical injection, demonstrating stable water chemistry control and improved system integrity. In addition, resin life was significantly extended, and both chemical consumption and wastewater generation were markedly reduced.

4. Conclusion

The amine breakthrough approach successfully enabled high-pH operation in nuclear secondary systems, reducing corrosion products and optimizing chemical usage. The method provided both economic and environmental benefits by lowering chemical consumption and waste generation while maintaining compliance with management control limits. The operational lessons from Kori Unit 3, particularly the challenge of ammonium accumulation, were resolved by introducing a parallel cation bed in OPR/APR units. This strategy allowed stable pH control and paved the way for standardized application. KHNP plans to extend this practice to additional OPR and APR units, beginning with Shinwolsong Unit 2 and Hanbit unit 5 in 2025. Accumulated field data will support further optimization, minimizing cation conductivity increases and sodium blips, and maximizing corrosion mitigation across the fleet.

REFERENCES

- [1] PWR Advanced Amine Application Guidelines-rev.2, EPRI, Palo Alto, CA:1997, TR 102952(rev.02).