Use of Macroporous Resin to Reduce Released Corrosion Products During Shutdown Evolution

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1. Introduction

During refueling outages of PWRs, the shutdown evolutions are performed to reduce corrosion products from the primary coolant water by controlling chemistry environments for the integrity of fuel performance. During the shutdown evolutions, the corrosion products, which are released from fuel and system surfaces, are removed by resin and filters at Chemistry and Volume Control System (CVCS). Recently, significant increases in activity releases have occurred during several PWRs shutdown evolutions as a result of changes in fuel duty, particularly excessive subcooled nucleate boiling, increases in cycle length and replacement of steam generators. The removal of activated corrosion products such as 58Co and 60Co which are released after hydrogen peroxide addition has been challenges for meeting cleanup limits for the corrosion products among PWRs, especially particles of less than 0.45 micro meter whose concentration is 2~5%.

For this reason, more than 33 PWRs in the world started using macroporous resins to improve the removal efficiency. Macroporous resins are known for their effective removal of micro particles by static electricity. Therefore, domestic Plant A applied a macroporous resin to increase the removal of micro insoluble corrosion products during shutdown evolutions. In this paper, we give preliminary results for effects of using macroporous resin at Plant A.

2. Materials and Methods

Macroporous resins are strong exchange resin with large pores which can capture effectively fine particulates associated with metal oxides. Plant A used a macroporous-type Purolite® NRW5070 during refueling outage (RFO) 20 and 21.

The macroporous resin of 100 L was added with the mixed resin of 700 L into the CVCS resin beds (800 L) before shutdown, as can be seen from Fig. 1. We added macroporous resin at the top of mixed resin and newly filled ion exchange resin bed was used during shutdown evolutions.

Table 1. Purolite® NRW5070 Information

<table>
<thead>
<tr>
<th>Items</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Capacity</td>
<td>1.0 eq/l (OH- form)</td>
</tr>
<tr>
<td>Moisture Retention</td>
<td>50 - 55 % (Cl- form)</td>
</tr>
<tr>
<td>Particle Size Range</td>
<td>425 - 1200 μm</td>
</tr>
<tr>
<td>Uniformity Coefficient (max.)</td>
<td>1.7</td>
</tr>
<tr>
<td>Conversion (min.)</td>
<td>95% (OH- form)</td>
</tr>
</tbody>
</table>

After peroxide addition, the RCS purification was started following 58Co peak detection. The clean-up continued with the purification flow rate of 20~28 m³/hr until reaching 24 hour cleanup or 58Co concentration peak being less than 3.7E+4 Bq/g. The key corrosion products (58Co and 60Co) were monitored to evaluate the total release of corrosion products by using HPGe (CAMBERRA, DSA1000). The corrosion product parameters and monitoring frequencies during shutdown are shown in Table 2.

Table 2. Monitored Primary Water Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Minimum Sample Frequency</th>
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</thead>
<tbody>
<tr>
<td>58Co (without filtering)</td>
<td>Every 4 hours</td>
</tr>
<tr>
<td>60Co (without filtering)</td>
<td>Every 4 hours</td>
</tr>
</tbody>
</table>
3. Results and Discussions

During shutdown evolutions in RFO 19–21, hydrogen peroxide of 25 ~ 45 kg was added to produce acid oxidizing conditions which solubilizes corrosion products such as radiocobalts. Fig. 2 shows that $^{58}$Co release trends during shutdown evolutions during the RFOs. $^{58}$Co release shows a steep increase following peroxide addition until reaching its peaks. After the peaks, $^{58}$Co concentration decreased during the following clean-up by filters and ion exchangers at CVCS.

![Fig. 2. $^{58}$Co trends during shutdown chemistry for RFO 19–21.](image)

$^{60}$Co concentration also showed a similar trend as observed for $^{58}$Co after hydrogen peroxide addition as in Fig. 3. Especially, $^{60}$Co activity at RFO19 is higher than at RFOs 20 and 21 where the macroporous resin was applied, showing that $^{60}$Co activity is effectively removed by the macroporous resin. As for $^{60}$Co purification trends, $^{60}$Co’s activity behavior is similar to $^{58}$Co after $^{58}$Co peak. These results shows that $^{60}$Co micro-particles were removed effectively by macroporous resin at Plant A.

![Fig. 3. $^{60}$Co trends during shutdown chemistry for RFO 19–21.](image)

Fig. 4 shows purification periods after hydrogen peroxide addition. At RFO 20 and 21 using macroporous resin, the clean-up took 19 and 13 hours which are shorter than 22 hours of RFO 19. Moreover, $^{58}$Co concentration at RFO 20 and 21 was significantly lower than that of RFO 19. Although cleanup were not effective at low $^{58}$Co concentration because micro particles mostly affect the RCS activity at that time. $^{58}$Co concentration was lowered effectively at RFOs 19 and 20 by using macroporous resin.

![Fig. 4. Purification Time after $^{58}$Co peak.](image)

4. Conclusion

Macroporous resin was applied at Plant A to remove micro particles which are not readily captured by filters resulting in problems of RCS purification. During shutdown evolutions at RFO 20 and 21, macroporous resin was applied as CVCS demineralizers. As results, cleanup periods which were needed for meeting cleanup limit (3.7E+4 Bq/g) were reduced by 15~51%.

Therefore, it was found that macroporous resin is an effective method to capture the micro particles at primary coolant water in PWRs thus thereby contributing to the reduction of cleanup time and RCS activity during shutdown evolutions.

REFERENCES