In Development

Conserve, Recover, Replace

EPRI Investigates How to Address a Vulnerable Lithium-7 Supply

By Sarah Stankorb

In 2014, a mechanical malfunction at a Chinese production plant led to a global shortage of lithium-7, the non-radioactive isotope used in western pressurized water nuclear reactors (PWRs) to control the pH of coolant water and minimize corrosion of fuel and materials. During the shortage, some nuclear plants with long-term contracts obtained lithium-7, while others received only partial orders.

“Eventually, many operators around the world were told that there was no more supply,” said EPRI Senior Program Manager Lisa Edwards. “While no plants ran out of lithium-7, some were close.”

Lithium-7 is produced only in China and Russia, making it vulnerable to shortages. Indeed, before the 2014 shortage, the U.S. Government Accountability Office pointed to the risks of the U.S. nuclear industry relying on just two suppliers.

The potential implications of a shortage are significant. Coolant water with a pH that’s too high or too low can lead to cracking of the reactor pressure vessel, nuclear fuel cladding failures, and higher radiation dose rates for workers. If a plant were to run out of lithium-7, it would have to use an alternative chemical. This would not happen because no alternatives have been qualified for use in western PWRs. In a technical investigation, EPRI found that the other naturally abundant isotope (lithium-6) cannot be used because it would generate unacceptable levels of tritium, a radioactive isotope of hydrogen.

“Lithium-7 is currently the only chemical qualified to control pH in the United States and many other countries,” said Edwards. “Qualifying any other chemical would require significant technical information for a safety evaluation to demonstrate that the change is low-risk. I don’t think that any plant would operate without pH control.”

Prompted by these supply challenges, EPRI has prioritized a three-pronged approach to mitigate potential lithium-7 shortages:

1. Use the existing lithium-7 supply more efficiently, while maintaining adequate inventories.
2. Recover and reuse lithium-7 from plant operations.
3. Find and qualify a replacement chemical.

The U.S. Department of Energy’s Office of Nuclear Energy is a key partner, providing $500,000 to support these efforts.

It could potentially take many years to demonstrate and qualify a different chemical. “A replacement might be the best long-term solution, but if a shortage occurs in the near term, plant operators will need a more immediate solution,” said Edwards. “That’s why we’re also looking at conservation and recovery options.”

Conservation

EPRI researchers analyzed the lithium-7 practices among EPRI-member utilities and found that the amount used in PWR fuel cycles varies widely. Drawing from industry experiences and best practices, EPRI published a report to help plants minimize the amount used. This analysis confirmed that the savings are likely small, and another solution is required.

Recovery

Lithium-7 is generated in PWRs through a nuclear reaction in the reactor core. EPRI is evaluating processes to recover this lithium-7 from waste resin, which also contains radioactive metals such as nickel, iron, and cobalt, and is typically disposed of as low-level radioactive waste.

EPRI lab-tested two chemicals that can potentially be used to separate lithium-7 from the resin—sulfuric acid and ammonium bicarbonate—and both recovered more than 90% of the lithium-7. EPRI is evaluating which process is more effective, with published results expected later in 2017.

“It is currently cheaper to buy new lithium-7 than to recover it,” said EPRI Principal Technical Leader Dennis Hussey. “But if supplies again become limited, recovery could become cost-effective.”

Replacement

While lithium-7 is the only chemical qualified for adjusting pH in western PWRs, VVER reactors typically use potassium hydroxide, and EPRI is investigating the feasibility of switching western PWRs to this chemical. In 2015, researchers evaluated the use of these chemicals in VVERs and PWRs and identified technical gaps that need to be addressed to enable such a switch.

Relative to VVERs, PWRs have different plant materials and a higher fuel duty, resulting in more deposits of corrosion products on fuel surfaces. The composition of these deposits and their impacts on fuel cladding need to be evaluated. Another area of investigation is the extent to which potassium hydroxide will impact the release of nickel from steam generator tubes in PWRs and form an isotope that causes radiation fields. Steam generator tubes in VVERs and western PWRs are made of different materials.

Adding an alternative chemical would necessitate that plant operators manage more chemicals. “Even though plant chemists will add potassium hydroxide for pH control, lithium-7 generated during the fuel cycle will also be present,” said EPRI Senior Technical Executive Keith Fruzzetti. “To maintain pH in the proper range, chemists will have to control both the potassium and lithium concentrations.”

If operators were to switch to potassium hydroxide, they could use the same injection systems currently used with lithium-7. Potassium hydroxide is abundant and less costly than lithium-7. EPRI estimates that the switch could save each reactor approximately $100,000 per year.

Use of potassium hydroxide may provide other benefits beyond cost savings and independence from a vulnerable lithium-7 supply. Preliminary analysis indicates that potassium hydroxide can reduce the susceptibility of fuel to crud-induced power shifts, which can potentially lead a plant to reduce its power rating and incur a significant financial loss. EPRI will also evaluate whether potassium hydroxide could help to reduce irradiation-assisted stress corrosion cracking in plant components.

For the next phase of qualification, EPRI in 2020 will begin a demonstration of potassium hydroxide in a western PWR. It has formed an advisory committee of U.S. utilities and international VVER operators to gather technical input for the tests and analyses during qualification.

Fortunately, no plants in the United States have run out of lithium-7 for pH control. “But contemplating how a plant would respond to a shortage makes people uncomfortable enough to know that this is a vulnerability we need to address,” said Edwards.

Key EPRI Technical Experts

Lisa Edwards, Keith Fruzzetti, Daniel Wells, Dennis Hussey, Joel McElrath