**Get the Iron Out: Oyster Creek Pioneers Fiber Technology for Feedwater**

Exelon Corporation’s Oyster Creek Generating Station has pioneered in the United States a Japanese hollow fiber filtration technology that reduces feedwater iron concentrations to previously unattainable levels.

EPRI’s *Boiling Water Reactor Water Chemistry Guidelines* (1016579) identifies the following benefits associated with reducing feedwater iron:

- Prevents excessive buildup of tenacious crud on the fuel, which can contribute to fuel failures
- Minimizes cobalt 60 transport and corresponding radiation dose rates
- Optimizes zinc injection to suppress radiation field buildup

Recognizing these benefits, North American boiling water reactor (BWR) operators reduced the fleet’s average feedwater iron level from 2.54 parts per billion (ppb) in 1997 to 0.7 ppb in 2008, primarily through high-efficiency iron filtration technologies.

Oyster Creek had reduced feedwater iron from more than 5 ppb in the 1980s to 2–3 ppb in the late 1990s—levels that did not meet EPRI guidelines of 0.1–1 ppb or Exelon’s long-term chemistry goals for asset protection. Moreover, maintaining the plant’s reactor water chemistry with the existing condensate polishing system presented a significant operating cost.

Studies in 2001 showed that retrofitting a condensate filtration system upstream of the plant’s deep-bed demineralizers would reduce operating and maintenance costs and lead to lower drywell radiation dose rates through more effective use of depleted zinc oxide.

**Selecting Hollow Fiber Filtration**

Retrofits of condensate prefilters upstream of deep-bed demineralizers in North American BWRs have exclusively employed pleated-filter technology. In Japan, however, hollow fiber filter technology has been used extensively and successfully in both nuclear and fossil condensate filtration applications.

EPRI tested the technology in the 1990s at PSEG’s Hope Creek Generating Station and determined it to be technically superior. At that time it was considered uneconomical, compared with pleated-filter technology, and it had not been demonstrated in full-scale condensate applications in the United States. Subsequent design improvements have enhanced the economics, and the costs for U.S. plants can be further reduced by manufacturing the vessels domestically.

After its own analysis, Exelon installed hollow fiber filters in the main condensate flow path by means of piping tie-ins to the condensate header between the condensate pumps and the deep-bed condensate polishing system. Within days, the prefiltroffluent iron was less than 0.1 ppb, and feedwater iron dropped from 3–4 ppb to less than 1 ppb. Feedwater iron levels continued to decrease as condensate demineralizer resin beds were cleaned or replaced.

After a mid-cycle maintenance outage in 2008, the first feedwater iron sample showed an iron concentration of 0.84 ppb—the lowest value ever measured during a startup at Oyster Creek. Reduced feedwater iron will allow Oyster Creek to achieve goals for the reactor coolant cobalt 60 (soluble)/zinc (soluble) ratio while maintaining feedwater zinc at less than 0.4 ppb, as recommended in the EPRI guidelines.

Hollow fiber filtration offers the following features and benefits:

- **Long life**—Pleated-filter septa have an average useful life of 3–4 years, whereas hollow fiber filters at Fukushima Unit 4 have demonstrated module life of more than 14 years, with no indication of failure. (The unit’s inlet iron, temperature, and flow conditions are comparable to those at Oyster Creek.)
- **Minimal ancillary equipment**—Hollow fiber filter technology does not require an air receiver tank, air compressor, or backwash receiving tank to support filter backwash.
- **Radwaste reduction**—Liquid radwaste from condensate operations is reduced by 98%. During the first year, Oyster Creek reduced liquid radwaste by 1.25 million gallons.
- **High (99.8%) availability**—An 80-day interval between hollow fiber filter cleaning operations provides an extended system on-line period without inputs to the radwaste plant, facilitating radwaste maintenance planning and thus improving radwaste plant reliability.
Further Work
EPRI and Exelon continue to monitor the system, and EPRI is helping other utilities with evaluations. An EPRI report, *Evaluation of Hollow Fiber Filtration for Condensate Polishing Application* (1014714), provides an overview of hollow fiber filtration in nuclear applications and is available to all EPRI members.

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Developing a Sustainable Nuclear Fuel Strategy
The success of nuclear power depends in part on a long-term commitment to the safe handling and disposition of used nuclear fuel and other waste streams. Countries with nuclear power programs—or with aspirations to nuclear power programs—should understand that the sustainability of these programs depends on effectively addressing technical, security, economic, public relations, and political issues regarding used fuel.

“Nuclear power plant operators have a near-term responsibility for managing the spent fuel that is produced by their operations, but operators in the United States currently have little choice but to store the spent fuel at the reactor site,” said EPRI senior technical executive Albert Machiels. “There is no other outlet for this material: no central storage facility, no repository, and no place where the spent fuel could eventually be reprocessed and refabricated into new fuel elements.”

In September, EPRI released *Advanced Nuclear Fuel Cycles—Main Challenges and Strategic Choices* (1020307). The report discusses four main areas that must be considered in developing a sustainable nuclear fuel program: sustainability of natural resources, waste management, nonproliferation, and economic competitiveness. The relative importance of these issues is different for each country, and the report looks in depth at how they are addressed in the two largest nuclear power producers: France and the United States.

“There is a marked difference between how the two countries are proceeding,” said Machiels. “In the U.S. we have an economy that is mostly market driven, while in France the nuclear policy is driven by the government.” The market-driven nature of the U.S. situation has reduced the value of reprocessing because it has been cheaper to acquire new fuel for reactors than to reprocess used fuel. France’s emphasis on energy security emphasizes fuel independence, making fuel reprocessing more viable.

The report concludes that, while the strategies of countries or regions will differ, a sustainable nuclear fuel cycle should have three fundamental attributes:

1. It should rely on the energy content of U-238, which represents more than 99% of natural uranium. A partially closed fuel cycle with fast reactors, in which fertile U-238 is converted into fissile Pu-239, is currently the most attractive advanced option. Another possibility is the thorium fuel cycle, in which fertile Th-232 is converted into fissile U-233. However, much less work has been conducted on the thorium fuel cycle, and its supporting infrastructure is still in its infancy.
2. It has to be as simple as possible. Simplicity is critical for operational, economic, licensing, and public acceptance reasons. Many options are on the table, and many represent dramatic departures from the current situation. What works on paper, however, does not necessarily work at an industrial scale.
3. It must remain focused on cost-competitive power generation. Certain options may become unrealistic if they prescribe the transmutation of all transuranics and fission products or excessive steps to make nuclear materials proliferation-resistant. Waste disposition and proliferation risks must be addressed in ways that are safe, secure, and pragmatic.

“Any rational fuel-cycle policy has to be focused on the fact that we are in the power generation business, and the goal is to produce power,” said Machiels. “There are many technologies that could be used, but you want to make sure you choose an option that will be reliable and economically provide the power that is required.”

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