RESEARCH AND DEVELOPMENT

PPPL proposes plasma-based waste treatment method

Princeton physicists have developed a new, cost-effective process for treating radioactive waste that could reduce the amount of waste to be vitrified for long-term storage.

In an effort to reduce the volume of nuclear waste and the costs associated with treating it, physicists at the Department of Energy's Princeton Plasma Physics Laboratory are proposing the use of a plasma-based centrifuge method to separate nonradioactive elements from radioactive waste. Known as plasma mass filtering, the new separation technique would supplement chemical techniques. Announced by PPPL on December 2, the research results first appeared in the paper "Plasma Filtering Techniques for Nuclear Waste Remediation," which was published in the October issue of the *Journal of Hazardous Materials* (Vol. 297).

Noting the challenge of safely treating radioactive waste, Renaud Gueroult, PPPL staff physicist and the paper's lead author, said that supplementing existing chemical separation techniques with plasma separation techniques "could be economically attractive, ideally leading to a reevaluation of how nuclear waste is processed."

According to PPPL, the research was motivated by the large volume of radioactive waste currently stored at the DOE's Hanford Site near Richland, Wash. Approximately 56 million gallons of mixed radioactive and chemical waste is contained in 177 underground tanks at Hanford, waiting to be converted into a stable glass form through the vitrification process. The construction of Hanford's Waste Treatment and Immobilization Plant, which is being built to vitrify the waste, has been delayed due to technical issues. Originally expected to be completed by 2011 at a cost of $4.3 billion, the DOE has now proposed a startup date of 2039. According to a May 2015 audit report from the U.S. Government Accountability Office, since 1989, the DOE has spent more than $19 billion on managing Hanford's tank waste. Separating and packing more high-level radioactive waste into fewer glass canisters would help reduce vitrification and disposal costs, PPPL said.

According to PPPL, the high throughput plasma-based mass separation techniques advanced at the laboratory offer the possibility of reducing the volume of waste that needs to be vitrified. In a press release, Nat Fisch, coauthor of the paper and director of the Princeton University Program in Plasma Physics, said, "The interesting thing about our ideas on mass separation is that it is a form of magnetic confinement, so it fits well within the laboratory's culture. To be more precise, it is 'differential magnetic confinement' in that some species are confined while others are lost quickly, which is what makes it a high-throughput mass filter."

Plasma mass filtering begins by atomizing and ionizing the hazardous waste and injecting it into a rotating filter so that the individual elements can be influenced by electric and magnetic fields. The filter then separates the lighter elements from the heavier ones by using centrifugal and magnetic forces. The lighter elements are typically less radioactive than the heavier ones and often do not need to be vitrified. Therefore, processing the HLW would require fewer high-level glass canisters overall, while the less-radioactive material could be immobilized in a less costly waste form, such as concrete or bitumen, according to PPPL.

Gueroult noted that solid waste can be ionized for about $10 per kilogram in energy costs, while the total cost of chemical-based techniques can be $2,000 per kg of vitrified waste. "It stands to reason that even if several plasma-based steps are needed to achieve pure enough separation, there is, in principle, plenty of room to cut the overall costs," he said.

The new technique also would be more widely applicable than traditional chemical-based methods, since it would depend less on the nuclear waste's chemical composition, PPPL said. While the performance of the plasma mass filter would be influenced in some ways by waste composition, Gueroult said, the effect would most likely be less than that associated with chemical techniques.

According to Fisch, the idea for plasma mass filtering grew out of a thesis by Princeton doctoral student Abe Fetterman, who, he said, "began by considering

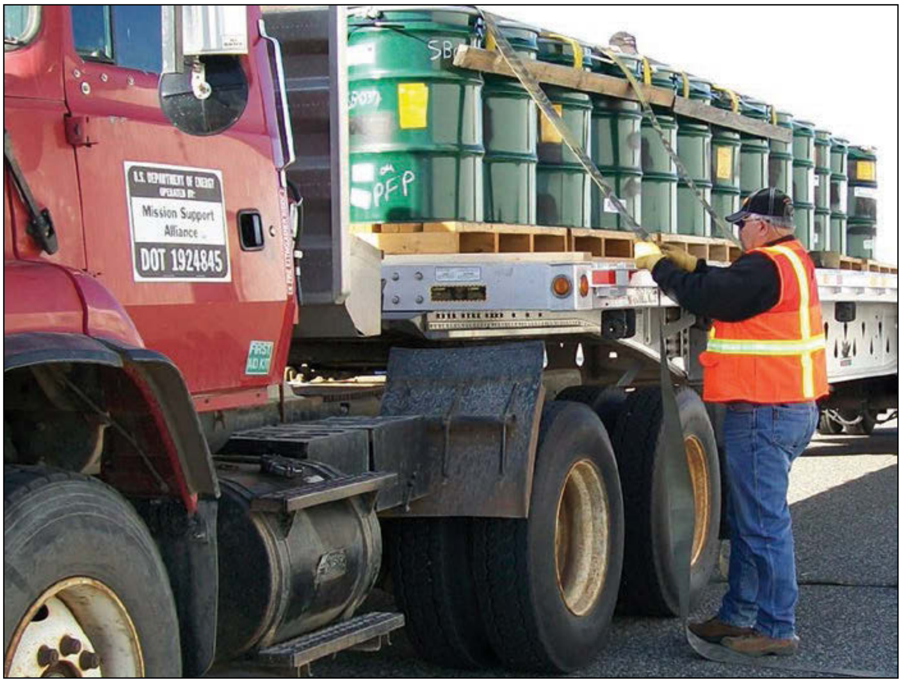

Photo: DOE

A shipment of mixed low-level waste from Hanford is secured for treatment and disposal.

centrifugal mirror confinement for nuclear fusion, but then realized the potential for mass separation." The current developments are a variation and refinement of a plasma-based mass separation system first advanced by Archimedes Technology Group, a private company that developed a plasma-based centrifuge concept to clean up the legacy waste at Hanford but ceased operation in 2006 after failing to receive federal funding, Fisch said.

The work on plasma mass filtering was supported by PPPL's Laboratory Directed Research and Development Program.

DECOMMISSIONING

NRC grants Vermont Yankee EP exemptions

The Nuclear Regulatory Commission has granted Entergy Nuclear Operations' request for exemptions from certain emergency planning (EP) requirements under 10 CFR Part 50, allowing the company to alter the emergency preparedness plan for the Vermont Yankee nuclear power plant in Vernon, Vt. The exemptions will reflect the plant's decommissioning status and become effective on April 15.

Under 10 CFR 50, EP requirements continue to apply to a nuclear power reactor after permanent cessation of operations and removal of fuel from the reactor vessel. Because there are no explicit regulatory provisions distinguishing EP requirements for a power reactor that has been shut down from those for an operating reactor, licensees that are transitioning to decommissioning must seek exemptions from certain EP rules before amending these plans to reflect the lower risk associated with a permanently defueled facility. Entergy closed Vermont Yankee, a single-unit boiling water reactor, on December 29, 2014. All spent fuel has been per-

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