Syd Koegler, codeveloper of the SC CO_2 process, standing beside the pilot plant.

Radioactive Waste Not Wasted with New Green Chemistry Technology

Green chemistry will help Areva extract enriched uranium from tons of incinerator ash.

By Thomas Smith and Judy Thomas

Fuel America Areva NP Inc. and the University of Idaho are using green chemistry to take sustainable development to a new level. When faced with the challenge of extracting enriched uranium from 32 metric tons of incinerator ash at Areva's uranium fuel plant in Richland, Wash., Syd Koegler, an Areva engineer, and Chien Wai, a University of Idaho researcher, turned to an environmentally friendly solution.

Disposable solid waste generated by normal plant operations is reduced by a factor of 25 to 1 through a carefully controlled incineration process. Chemical analysis determined that the 32 tons of accumulated waste ash awaiting final disposal contained more than 2 tons of enriched uranium—worth about $5 million in today's market.

"Sustainable development is always uppermost in our thinking and planning at Areva," said company Vice President Joe Zwetolitz. "By recovering such a valuable energy resource that otherwise could have been lost to disposal and by using an environmentally sensitive process to do it, it's a win-win result for our planet and for Areva."

Supercritical Carbon Dioxide

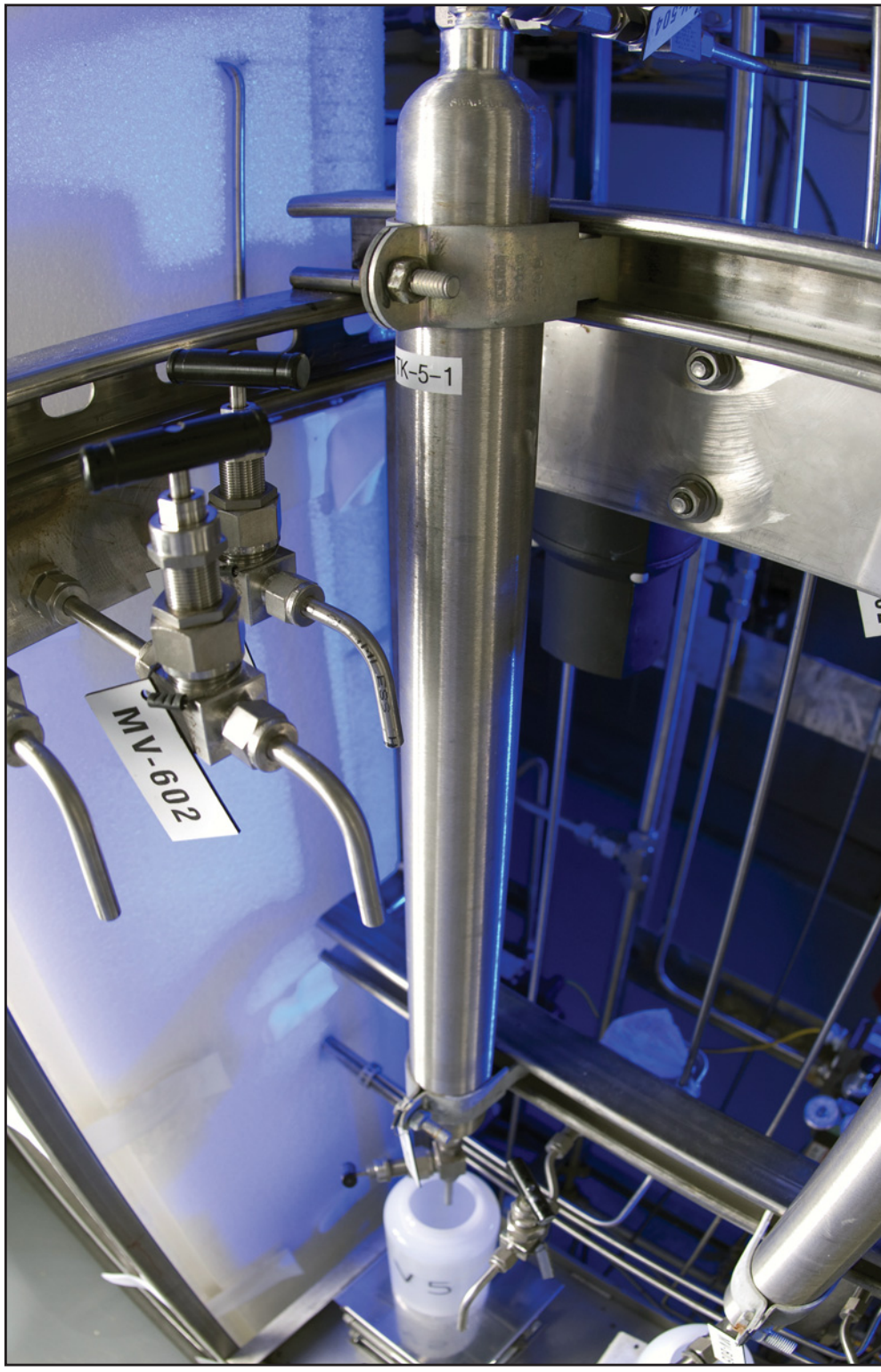
The process is similar to the one used to remove caffeine from beverages or to produce certain pharmaceuticals. It involves using a liquid-like "supercritical" (SC) form of carbon dioxide in conjunction with other common chemicals to extract and purify the enriched uranium. Carbon dioxide reaches its supercritical state at a pressure of 1000 pounds per square inch and a temperature of 31°C. Supercritical carbon dioxide offers significant industrial-use benefits, because it is chemically inert, nontoxic, and relatively inexpensive compared to other solvents.

The Areva uranium recovery process will recycle the carbon dioxide in a closed loop system to minimize any discharges to the environment. The recovery process also reduces other gaseous and liquid wastes.

The 800-square-foot ash-uranium recovery plant, being constructed at the Richland site this year, will have a small footprint. By 2009 it will be ready to receive ash from outside sources of low-level radioactive waste within the nuclear power and nuclear medicine industries, for example.

Koegler and Wai have worked together for four years on the uranium extraction project, and they have applied for a joint patent for the green process to recover uranium from incinerator ash. This new recovery process was proven to remove more uranium and with better economics than any other processes, resulting in Areva's decision to go forward with the project.

"The SC CO_2 Uranium Recovery Project is significant because it is the first such application of this exciting new technology in the nuclear industry," said Koegler. "It offers a cleaner, cheaper method to recover and recycle a valuable commodity from material that previously was considered waste. From a business perspective, we're adding another important technology to Areva's portfolio of products and services."



Sample ports for collecting liquid samples from the SC CO_2 pilot plant.

Techniques Developed in the Early 1990s

The techniques for extracting metal species using supercritical fluid carbon dioxide as a solvent were developed at the University of Idaho in the early 1990s. A series of papers published by Wai's research group over a 15-year period described potential applications of this technology for decontaminating toxic metals and treating radioactive wastes. The Idaho Research Foundation holds seminal patents for this technology.

The process uses the green solvent SC CO_2 for dissolution, extraction, and separation of enriched uranium from solid waste, with minimal secondary waste generation. The process does not require conventional organic solvents, and the carbon dioxide can be recycled for repeated use. This new green technology is not limited to treating radioactive wastes; it can also be used for remediation of toxic metals. According to Wai, it could even be useful for recycling spent nuclear fuel. "The supercritical fluid technology may have a wide range of applications for the environmental problems we are facing in the 21st century," added Wai.

Howard Clemetson, with Areva, installs the removable insulation on the extractor vessels in preparation for starting up the pilot plant.

The SC CO_2 Demonstration Project

Always searching for innovations to apply to Areva's product and service offerings, Koegler learned about Wai and his SC CO_2 uranium technology through a friend and colleague in 2002. "I could see that this technology could hold many advantages over traditional methods for uranium recovery, so I contacted him and we began our collaboration," said Koegler. Areva saw promise in Wai's work and began providing funding support for his research and demonstration project in 2003.

"It has been a natural partnership with Dr. Wai contributing advanced chemistry knowledge with my 30 years of research and development experience in the nuclear power industry," said Koegler.

The SC CO_2 Uranium Extraction Demonstration Project began in the spring of 2003 with a three-phase approach: (1) demonstration of technology, (2) pilot-plant testing, and (3) design and construction of a processing plant.

Phase 1 involved supercritical fluid extraction experiments in Areva's lab under Wai's supervision. Phase 2 began in 2005 with construction of a 400-ft^2 pilot plant within the Richland facility. The pilot plant processed about 2 kilograms of ash per batch. Phase 3 started in 2007 with Koegler leading Areva's engineers in the design of the actual plant. Wai and Koegler continue to collaborate on developing other potential applications of the technology to address nuclear waste–related problems.

A joint Areva–University of Idaho invention disclosure was filed with the Idaho Research Foundation in December 2003. The partnership filed a U.S. provisional patent application entitled "Method and System for Recovering Metal from Metal-Containing Materials" in January 2005, a formal U.S. patent application in January 2006, and a PCT International application in 2007.

A Positive Impact on Public Opinion

The uranium recovery plant will process about 120 kg of ash every eight hours, a normal working shift. The existing 32 tons of ash will be processed in a little more than a year's time, with one eight-hour shift running per day. Spent ash will ultimately be deposited in a licensed low-level radioactive waste disposal facility. The plant's wastewater treatment facility will treat liquid effluent onsite.

Wai believes this new technology may have a positive

Uranium-containing incinerator ash used in pilot plant tests.

impact on public opinion regarding nuclear energy. "Nuclear energy does not emit carbon dioxide and does not contribute to global warming," said Wai. "Currently nuclear power accounts for 80 percent of the electricity in France, but it contributes to only about 20 percent of the U.S. electricity production. One public concern regarding nuclear power is the radioactive waste disposal problem. If the green technology developed by Areva could be used for managing certain nuclear wastes, nuclear energy would be much more acceptable to the public." ■

Tommy Smith works in Media Relations for Areva NP Inc.; Judy Thomas is Areva's Richland site communicator. For additional information, contact Thomas.Smith@areva.com.