Polycube stabilization completed at PFP

Michele Gerber, *Fluor Hanford*

A PFP worker handles a polycube inside a glovebox.

Plutonium Finishing Plant personnel have finished stabilizing one of the riskiest forms of plutonium-bearing materials at Hanford. Polycube items, part of the metals/oxides/polycubes collection, are small cubes of polystyrene impregnated with pure plutonium oxide. Hundreds of polycube items remained at PFP after being fabricated for use in criticality experiments at Hanford during the 1960s and early 1970s.

Although the polycubes are small — the largest being 2-inch cubes — the risks associated with this unique form of plutonium made stabilizing polycubes a priority for the Department of Energy Richland Operations Office and the Defense Nuclear Facilities Safety Board, an arm of Congress.

"The important outcome is that we did it," said Fluor Hanford senior scientist Susan Jones, a member of PFP's technical team that worked for more than a year to develop safe parameters and procedures for stabilizing the polycubes. "The polycubes had posed difficult issues for us for many years. They had to be stored in vented containers, and they emitted radiation every time they were handled, moved or inspected. In addition, the composition of polycubes was unique, and we didn't have a proven method to stabilize them for safe, long-term storage. The success of the polycube stabilization campaign is momentous to everyone involved, and definitely eliminates a high-risk component of the Hanford Site."

Polycubes posed unique challenges for several reasons. First, they were fabricated by combining plastic powders with mixed-oxide (plutonium and uranium) powders, heating the mixture in molds until the plastic matrix fused, and then wrapping the cubes in plastic tape for abrasion resistance. During years of storage, some of the plastic disintegrated through radiolysis (chemical decomposition resulting from radiation), and some portions of the cubes crumbled into sandy particulates resembling table sugar or mush.

Second, the cubes generated hydrogen during storage, so they had to be stored in vented containers in PFP's vaults. The vents used filter paper, similar to that used in continuous air monitors, to reduce possible airborne radionuclide releases in the vaults. As the plastic tape around the filter paper degraded over time, it further compounded the stabilization and handling challenges.

Developing the process

When PFP scientists began pre-stabilization testing in the 1990s, they discovered that the radiolyzed plastics added highly toxic fumes to the off-gases, or vapors, driven off during thermal stabilization. Soot and flammable gases were readily formed — especially if the cubes were heated too fast — requiring costly filter replacements and exposing workers to increased doses of radiation.

To solve the problem, the scientists conducted extensive tests and developed a long and complicated "char cycle" that required heating the cubes through a specific process in special metal "boats" in furnaces that were inside gloveboxes. The charring process burned off the polystyrene and other plastics, and left dense plutonium oxide powder that workers could place in sturdy long-term storage containers.

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"The volume, the timing and the exact temperature cycles all had to be watched carefully over an evolution that took three days, meaning it took six shifts to run about eight cubes," said Fluor Hanford Thermal Stabilization and Polycubes manager Rob Cantwell. "During that entire time, filter conditions and off-gases also had to be precisely measured."

Cantwell has abundant praise for the PFP workforce. "I can't say enough about the crew of operators, maintenance and radiological control personnel, and others who did this polycube work," he said. "They were thorough, professional, innovative and dedicated. This was difficult work, and they did it beautifully."

The plutonium oxide that was generated through the polycube stabilization process was repackaged into stainless steel containers using a "bagless transfer system." Finally, it was welded into the outer "3013" can, meeting the strict specifications of DOE's 3013 standard for long-term plutonium storage.

With completion of the polycube campaign, Hanford's PFP has now stabilized the two forms of plutonium that posed the greatest risks — plutonium-bearing solutions and the small cubes.

Innovative procedures

Terry Merkling, lead PFP radiological control engineer for Fluor Hanford in the polycube stabilization program, headed a team that introduced several measures to reduce radiation doses for workers. Pewter cans were placed around the ordinary metal containers storing the cubes in the vaults, and workers who retrieved the cans and brought them to the furnaces wore leaded surgeon's gloves. Elastic "bonnets" were placed over the containers where tape had deteriorated.

Millwrights assigned to the project fabricated a unique set of tongs with a plate shield in front of a lead handle. The millwrights worked with Merkling's team to fabricate several versions before settling on ones that best protected the workers' hands. "We needed management support and a creative attitude to put these measures in place," said Merkling. "We got both. As a result, we experienced relatively low dose rates when you consider the work being done."

Fluor Hanford pipefitter Ed Woodard said maintenance crews developed and fabricated many one-of-a-kind special tools specifically for the cramped working spaces in the highly radioactive gloveboxes, along with the associated piping and filters.

"Some of the cavities and equipment configurations were almost impossible to reach," said Woodard, "especially working in leaded gloves and two pair of surgeon's gloves, with leather gloves over all of those." Each of the filters used to trap radioactive gases from the five furnaces used in the program had to be changed about every other week. Each filter housing weighs about 70 pounds and is located above the workers' heads. Often, the filters and piping were distended by the intense heat of the stabilization process (1,000 degrees Celsius for many hours). Each piping replacement involved more than 12 pipe components.

Woodard and a team of other pipefitters, electricians, instrument technicians, millwrights, operators, insulators, laboratory technicians, chemical technicians and radiological control technicians devised their own wrenches, gaskets, caps and a special "pusher" tool to hasten the many filter changes. They reduced the time it took them to change filters from almost two days to half a day. "Our main goal was to find ways to speed up the work and get out of the radiation zones," recalled Woodard. "Less time equals less dose. We were motivated to find better ways to get it done."

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More challenges

Polycubes continued to challenge the workers. The high radiation doses, inconsistent sizes of polycubes within various items, high waste volumes, plugged filters in the middle of runs, flare-ups of the plastic tape and occasional “puffs” of the residual plutonium oxide powder kept workers on their toes. “We had to keep track of the criticality postings and re-evaluate conditions constantly,” said Fluor Hanford nuclear chemical operator Brett Martin. “The dose rates actually went up as the polystyrene burned away, so we were continually figuring out ways to lower dose and time for every aspect of the job.” They broke waste packages down into smaller packages and took them away in pewter cans. It was one of the first times pewter cans have ever been used for waste handling at Hanford.

Fluor Hanford PFP Q-shift manager Dave Romine said the polycube stabilization campaign touched every person at PFP — every work group, including administrative people, all DOE personnel at PFP, and even many people in downtown offices who worked on technical analyses and procedures. “This was a huge team effort, and we all benefited,” said Romine. “We saw a radiation-level reduction in the vault storage areas almost immediately after we started stabilizing polycubes. This was important work, and I’m proud of every single person who participated.”

In addition to the polycubes, all of the plutonium metals and solutions at the plant have been stabilized, and miscellaneous oxides are about 25 percent complete. Also, about 95 percent of the other large group, the residues, have been stabilized.

The Fluor Hanford Nuclear Material Stabilization Project, which operates the PFP complex, plans to complete stabilization of the entire inventory of plutonium-bearing materials by February 2004. ■