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ACTINIDE RESEARCH QUARTERLY

2nd quarter 2002

Researchers cast first "spiked" plutonium alloy

Major success in replicating how the stockpile ages

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- **Technology transfer between Savannah River and the national labs**
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- **"Eye of the Beholder"**

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NATIONAL LABORATORY

Nuclear Materials Research and Technology

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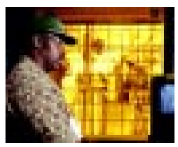

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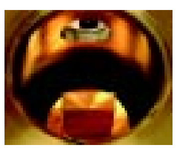


ACTINIDE RESEARCH QUARTERLY highlights recent achievements and ongoing programs of the Nuclear Materials Technology (NMT) Division. We welcome your suggestions and contributions. ARQ can be read on the World Wide Web at: http://www.lanl.gov/orgs/nmt/nmtdo/AQarchive/AQhome/AQhome.html.

LALP-02-061

ABOUT THE COVER

photo by Joe Martz

Claudette Trujillo of the Nuclear Materials Science Group (NMT-16) assists with rolling an enriched plutonium cookie on a laboratory-scale rolling mill during the historic casting of a "spiked" plutonium alloy May 13. Cold-rolling the as-cast plutonium emulates the process used at the Rocky Flats Plant to manufacture weapons components. To provide even more credibility to the process, the same grade of oil previously used at Rocky Flats, Texaco Regal®, was used to lubricate the plutonium during rolling. The background image is of an enriched plutonium specimen mounted inside an aluminum fixture that will be tested using a 40-mm launcher. The story begins on the next page.

Major success in replicating how the stockpile ages

Researchers cast first "spiked" plutonium alloy

Los Alamos researchers celebrated a major success May 13 when they cast the very first "spiked" plutonium alloy, creating an accelerated-aging alloy that should age at a rate sixteen times faster than normal. As a result, in four years the researchers hope to have a material representative of sixty-year-old plutonium.

Researchers will measure the spiked material to look for any age-related changes in key physics, engineering, and materials properties. On the basis of these experiments, they'll determine if the nation's stockpile pits will last at least sixty years.

"This is probably the most technically difficult project we have ever attempted, at least metallurgically, at TA-55," said J. David Olivas, technical lead on the project and former Rocky Flats scientist.

photos by J. David Olivas

The photo at right shows the plutonium-238 metal button that was used as the starting material for the May 13 enriched casting. Plutonium-238 is normally only available in the form of plutonium oxide because its radioactive decay produces so much heat that the material must be present as a ceramic for it to be stable. The plutonium-238 button shown here was reduced to the metal form from oxide originally fabricated for space-program heat sources. Personnel in the ^{238}Pu Science and Engineering Group (NMT-9), who followed a procedure developed at DP Site in the 1970s, performed the reduction. This was the first time that plutonium-238 metal had been fabricated at TA-55. This button weighs about 100 grams and is sitting at about 200 degrees Celsius.

The experiment required years of preparation and included replicating the Rocky Flats plutonium manufacturing process. To that end, Los Alamos researchers had to set up a capability that had never existed before: a one-of-a-kind small-scale casting, rolling, and machining operation at the Laboratory's Plutonium Facility (PF-4). The researchers also had to reproduce key process steps and produce a material that matched Rocky Flats specifications in a number of important properties.

And they did it on the first try.

The research endeavor, called the Accelerated Aging of Plutonium (AAP) Project, is an experimental collaboration between Los Alamos and Lawrence Livermore National Laboratories. Besides Olivas, the AAP team at Los Alamos consists of Franz Freibert, principal investigator; Richard Ronquillo, lead mechanical technician; Claudette Trujillo, materials accountability specialist; Chris Trujillo, mechanical technician; and David Dooley, graduate research associate. All are with the Nuclear Materials Science Group (NMT-16).

These Los Alamos scientists, working with others in NMT-16, the Structure/Property Relations Group (MST-8), and the Detonation Science and Technology Group (DX-1), will examine the spiked material

"Spiked" Plutonium Alloy

Chris Trujillo of the Nuclear Materials Science Group (NMT-16) machines a Kolsky test specimen. A non-water-based coolant is used to flood the specimen during machining. Flooding ensures that the sample is not overheated during the machining process, avoiding the introduction of nonaging-related artifacts into the plutonium sample.

with advanced characterization tools to measure aging-related changes in physical and chemical properties. Scientists at Livermore are conducting a parallel materials production and sample preparation activity. The two laboratories will exchange information and samples.

The AAP activities support the Enhanced Surveillance Campaign goal to protect the health of the stockpile by examination of aged plutonium through the accelerated production of defects.

The information obtained from this research will be used to predict material and component aging rates as a basis for annual certification, refurbishment scope and timing, and nuclear weapon complex planning.

Ultimately, this work will form the key basis for establishment of pit lifetimes. Results of the research will also be used to make improvements to the basic surveillance program (see ARQ 1st quarter, 2001).

The new casting and machining capability also will enable Nuclear Materials Technology (NMT) Division to expand its research and development efforts in the study of weapons-related actinides and other special isotopes and materials.

Aging weapons alloy and stockpile stewardship

Researchers spiked the plutonium alloy cast May 13 with isotopic blends containing 7.5 percent plutonium-238. The greater alpha decay rate of the plutonium-238 isotope accelerates the self-irradiation process and enhances the self-irradiation damage as a function of time. Accelerating the self-irradiation aging effects in weapons alloys should provide critical data at extended effective lifetimes in the manifestation of aging effects on weapon design parameters and component function, according to the researchers.

The casting yielded nine enriched plutonium "cookies," one of which is shown here. The thickness of this miniature ingot duplicates the thickness of the Rocky Flats ingots, giving researchers a good simulant for the next stage of processing: rolling the ingot into a sheet.

The detection and prediction of changes in an aging stockpile are perhaps the most challenging and technically engaging aspects of science-based stockpile stewardship. Originally, weapons systems were designed with the expectation that the nuclear components would provide a reasonable lifespan and that the systems would be modernized or replaced on a consistent basis. Weapons systems were not designed with the goal of long-term (fifty or sixty years) robustness.

Given the current constraints and conditions in the nuclear weapons stockpile, systems will require extended lifetimes for various components with only a modest remanufacture capability to replace excessively degraded units. Determining an appropriate response (recertification, refurbishment, or remanufacture) ultimately depends on an accurate assessment of individual component lifetimes.

The most acute challenge lies with testing and certification of plutonium components and the pits in which they reside. Previously, certification and recertification of the plutonium components relied heavily on full-scale nuclear tests—an approach that is no longer viable.

Relevant properties of weapons-grade plutonium and its decay products that affect performance include equation of state, spall and ejecta, material strength, density, geometry, corrosion resistance, and nuclear reactivity. Among the time-dependent phenomena that could affect the properties of weapons-grade plutonium are radiation-induced void formation and swelling; ingrowth of decay products such as helium, americium, and uranium; and phase instability. These effects may well be synergistic, making it particularly difficult to assess the importance of any one phenomenon by itself.

During the aging process, the enriched samples will be stored in incubators like the one in the photo at left. The samples will be cleaned before being loaded in the incubator chamber, and then will be stored in a pristine atmosphere for up to four years. Four years of storage in the incubator in actual time is equivalent to sixty years of aging in accelerated time. The samples will be removed periodically from the incubators and tested to obtain aging information at intermediate times. The incubator chambers were designed and built at Lawrence Livermore National Laboratory.

"Spiked" Plutonium Alloy

Red or green? The New Mexico question

A note on nomenclature

Using plutonium-238 to enrich weapons-grade plutonium resulted in the creation of a new material previously not used in the weapons complex. Addition of the plutonium-238 has led to the material being called by several names—spiked, enriched, and doped—all of which are acceptable.

Because this material is significantly different from other plutonium alloys, the researchers have chosen to name the material "Hatch." This is, of course, in honor of the southern New Mexico city that produces the regionally famous "hot" chile peppers.

Now, if they could just decide if Hatch qualifies as red or green.

Because of the lack of a suitable number and variety of aged plutonium samples, researchers sought to produce alpha-decay-induced damage at an accelerated rate. They accomplished this by adding relatively small amounts of the short-lived isotope plutonium-238, which has a half-life of 86.4 years, to weapons-grade plutonium-239. This technique simulates many years of aging in just a few years.

Experimental and theoretical approaches

The AAP researchers assume that the damage created by alpha decay of plutonium-238 is comparable to the damage that occurs in the normal material and that sensitive, fundamental measurement techniques can be employed to characterize this damage.

The spiked plutonium is being made into samples for many different experiments, and the data will give researchers a composite image of the aging process. A suite of advanced techniques is being used to characterize the enriched material and track subtle changes as the aging progresses. (See sidebar on page 7 for a description of the tests that are being used.)

"Most of these experimental techniques have been used in the past to study research-grade material, but this is the first time they will all be applied to the same material, and one that has such a well-known pedigree," said Freibert.

Testing diagnostic methods focus on assessing effects of extended aging on important design properties. Tests include density, dilatometry, elastic constants and bulk compressibility, conventional and high strain rate mechanical testing, x-ray diffraction, helium effusion, light and electron microscopy, and others.

These experimental capabilities will be applied to measure material properties sensitive to the reversible and irreversible thermodynamics of this plutonium alloy, as well as to provide information on the kinetics of aging-related processes. This information will provide a sound technical and scientific foundation for predicting weapon component lifetimes.

Researchers know from the analysis of nuclear reactor materials that the most obvious consequences of radiation damage are helium bubble formation and void swelling. The net effect is that the metal will swell and therefore reduce the density of the metal. Although there are other time-dependent phenomena that may affect the properties of weapons-grade plutonium, helium bubble formation and void swelling will unquestionably affect weapon performance.

Experiments using transmission electron microscopy (TEM) to image helium bubbles in weapons-grade metal have provided evidence supporting this theory (see ARQ 4th quarter, 2001). So far, the accumulation of aging effects and the overall impression on important weapons design properties are still quite speculative.

Fabrication "blitz"

The Los Alamos researchers are now in a fabrication "blitz" so that they can get experimental data near time equals zero. "That kind of data was missing at Rocky Flats," said Olivas. "It's not that Rocky Flats was not interested in scientific data, it's just that they were more interested in making the product to specifications. Information that was not part of the specification typically was not collected."

Working with the enriched plutonium has led to two independent challenges. "First, we must fabricate the enriched plutonium quickly, because once you make it, it starts aging," said Olivas. "To get time-equals-zero data, we need to make samples as quickly as possible, and then get them to the test station equally quickly." A twenty-three-day-old sample is about twelve months old in accelerated time.

Independent from the timing issue are the problems associated with the additional heat present in the samples from the presence of plutonium-238. Recall that plutonium-238 is normally used as a heat source. For example, the spiked material also appears to oxidize at an accelerated rate outside its storage environment.

"It started to oxidize within minutes of production, forcing us to conduct all our fabrication operations in very pristine atmosphere," said Olivas. The extra heat also makes taking measurements more difficult. "When we attempted to measure the density of one of the as-cast disks using the Archimedes method, we literally boiled the immersion bath fluid."

Previous work on a control casting

The May 13 spiked casting comes one year after a "control" material of the same chemistry, but significantly lower plutonium-238 isotopic content, was cast and machined to validate the installed equipment and thermomechanical processing.

A portion of the control batches received special processing to create samples with minute yet finite differences in physical and mechanical properties. These samples are now undergoing testing by a suite of diagnostics on a blind-sample basis to discern minute differences in physical and mechanical properties of plutonium alloys. Results will be used to quantify the sensitivity of the measurement methods.

Data from the spiked casting show that the density of the heat-treated spiked disks matches the density of the control casting

Personnel from the Nuclear Materials Technology (NMT) Division load extended x-ray absorption fine structure (EXAFS) and x-ray diffraction (XRD) test specimens into special containers. The specimens were shipped to the Stanford Linear Accelerator for testing. The containers isolate the plutonium beneath a special window and facilitate the testing of plutonium-bearing materials in facilities where nuclear materials are not normally handled.

photo by Fred Hampel

“Spiked” Plutonium Alloy

Tony Valdez of the Weapons Component Technology Group (NMT-5) loads the casting furnace with the precursor materials for the enriched casting: plutonium-239 metal “imported” from the Rocky Flats Plant and plutonium-238 metal buttons made at Los Alamos. For this casting, every effort was made to duplicate the processing parameters, such as heating and cooling, that were previously used at the Rocky Flats Plant to cast plutonium ingots. The metal is placed in a tantalum crucible, heated above the melting point of the plutonium, and then poured into the mold. All operations with molten plutonium are done in vacuum because of the extreme reactivity of the liquid plutonium.

disks at the same point in the processing. This is good news, according to Freibert and Olivas, because it indicates that metallurgically, Los Alamos’ processing for the spiked material was equivalent to that of the control casting.

More important, the researchers say, it also suggests that there seems to be no significant physical difference in the spiked material that may be attributed to adding the plutonium-238.

A work in progress

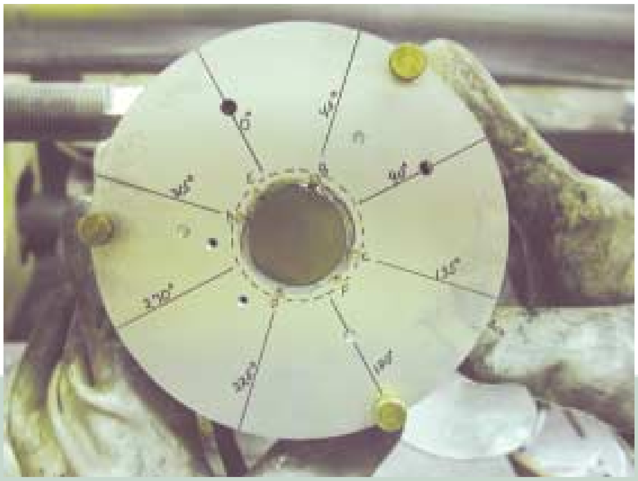
Progress on the enriched casting is proceeding nicely, according to Olivas and Freibert. As of this writing, all metallurgical processing has been completed, samples are being fabricated, and time-equals-zero testing has begun. The researchers have completed time-equals-zero testing on most of the mechanical property tests (40-mm launcher tests at high strain rate, Kolsky tests at intermediate strain rate, and compression tests at quasi-static strain rate), resonant ultrasound spectroscopy (RUS) tests, and x-ray diffraction tests.

In addition, they have shipped enriched plutonium to the Stanford Linear Accelerator Center for extended x-ray absorption fine structure (EXAFS) and x-ray diffraction (XRD) tests. ■

—Franz Freibert, J. David Olivas, and Meredith S. Coonley

One of the advanced characterization techniques being used at TA-55 to obtain data on the accelerated aging process is a 40-mm launcher, which is the equivalent of a cannon with a 40-mm-diameter bore. The big exception is that this cannon is located inside a glovebox. In the photo at the top of the next page, an enriched plutonium 40-mm launcher test specimen is mounted inside an aluminum fixture.

Testing material properties on the launcher consists of accelerating a quartz projectile down the barrel, impacting it against the face of the plutonium sample shown in the photograph, and using a velocity interferometer system for any reflector (VISAR) on the back face of the sample to observe the shock wave as it passes through the sample. To produce good results, the faces of the sample must be perfectly flat and parallel, typically to within plus or minus 0.0002 inches.



Diagnostics used to assess plutonium-aging effects

Diagnostic test	Information obtained by the test
Analytical chemistry	Isotopics, δ-phase plutonium stabilizers, and tramp elements (elements that are contaminated)
Density	Relative amounts of phases (α and δ) plutonium, helium, and void swelling
Optical metallography	Grain size, relative amounts of phases (α,α′,δ) plutonium, Pu_6Fe (an intermetallic compound that typically forms at grain boundaries), and inclusions
X-ray diffraction	Lattice parameters, relative amounts of phases (α, α′, δ) plutonium
Microprobe	Gallium segregation
Resonant ultrasound	Elastics constants, compressibility, and sound speeds
40-mm launcher	Dynamic mechanical behavior (spall strength and phase transitions)
Kolsky bar apparatus	Intermediate strain rate mechanical behavior
Tensile/compression	Quasi-static strain rate mechanical behavior (elastic-plastic properties)
Dilatometry	Thermal expansion, δ→α′ plutonium Martensite transition, and density changes
Part evaluation cycle	Phase stability (e.g., Stockpile to Target Sequence [STS], which is the order of events involved in removing a weapon from storage and assembling, testing, transporting, and delivering it on target)
Thermoelectric transport	Transport properties and isochronal annealing (damage recovery)
Thermal gas desorption	Gas species determination and helium trap energetics
Calorimeters	Phase transformations, transformation enthalpies, and specific heat
Helium effusion	Energetics of helium diffusion
Positron annihilation	Location and distribution of atomic-scale defects
Other	Surface science and local structure techniques

In metallurgy, the polymorphic phases of elements and alloys are identified by the Greek alphabet. Plutonium has seven phases; six at ambient temperatures and a seventh under pressure. Room-temperature α-phase plutonium has the lowest temperature and is brittle. δ-phase plutonium is stable at high temperatures and is very ductile, so it is easily formed into shapes.

In the photo below, an as-cast cookie sits in the immersion bath of the density measurement station. The decay from the plutonium-238 generates so much heat that it causes the immersion bath fluid, FC43, to boil. The boiling point of FC43 is 165 degrees Celsius. The bubbles are faintly visible as they rise above the surface of the cookie.

Division Review

Another outstanding/excellent rating

Annual review assesses the state of science and technology in NMT Division

Nuclear Materials Technology (NMT) Division is key to the national mission of reestablishing the capability to manufacture a pit and has the "awesome responsibility" of ensuring the reliability and safety of the nation's nuclear stockpile, said Rich Mah, associate director for Weapons Engineering and Manufacturing (WEM). Mah made the remarks at the opening session of the annual NMT Division Review.

NMT Division received an overall rating of outstanding/excellent from the external review committee, which met with members of NMT Division and upper management at Los Alamos May 14–16.

Areas under review were rated on four criteria: quality of science and engineering, relevance to national needs and agency mission, operation of major facilities, and performance of programs.

Three of the categories received outstanding/excellent ratings. The review committee rated a fourth category, relevance to national needs and agency mission, outstanding.

The review, required under the Department of Energy's (DOE) contract with the University of California, assesses the quality of the division's science and technology programs. Because all science and technology activities conducted by the division must be covered by the review within a three-year cycle, historically, about one-third of NMT Division's programmatic activities have been looked at each year.

In a break with previous practice, this year's review focused on facility management, material control and accountability, information management, and waste management.

Because these critical activities are essential to the success of so many of NMT's programmatic missions, the entire NMT management team felt they should be submitted for external review.

'Excellent progress'

In giving NMT Division its outstanding/excellent rating, the external review committee praised division management for making extensive changes and developing a more focused approach. In particular, the committee cited the division's making better use of statistical tools and numerical data to track programmatic performance and learn new approaches to operational excellence.

"The committee felt very strongly that the integrated approach to research, production, and facilities operation is demonstrably critical to programmatic success," the review committee members wrote in their report.

"Among its wide range of programmatic activities, the division's evidently successful commitment to pit production means that its contributions to national needs are self-evident," said the report. "Again, however, the integrated approach will continue to be critical because NMT has essential contributions to make to the [pit] certification process."

The committee cited the "excellent progress" made by NMT Division in the pit manufacturing area since the last review. Thirteen pits have been fabricated, including one early development pit, seven of nine developments, and five standard pits. The seventh development pit was fabricated fourteen months ahead of schedule.

Pit certification is running ahead of schedule, and the deadline has moved up two years from 2009 to 2007. Meeting the milestone two years early will save $450 million in the certification process, Mah told the opening session audience. The pit-manufacturing project also is on track to meet a major milestone in April 2003 with the completion of the Qual-1 pit.

While citing improvements in management, scientific excellence, and the success of the pit-manufacturing program, the committee recommended that the division place more emphasis on the development of a comprehensive strategic plan. "This is both urgent and important as programmatic success in the pit production area, for example, will likely mean that new responsibilities will be assigned to NMT in the near future," said the report.

Consequently, the report recommends that NMT and ADWEM develop a strategic plan that will address issues of "how major programs are expected to develop, space allocation within the limited amount of nuclear facility space, quality-of-life for the staff, and promotion of basic science and engineering to underpin the programs."

As a result of these suggestions, NMT managers, scientists, facility managers, and programmatic leaders will be meeting over the next two months to develop a comprehensive strategic plan for the division.

Aging facilities a major topic

Facility infrastructure and management were main topics of this year's review and discussion naturally focused on the Lab's nuclear facilities: the TA-55 Plutonium Facility (PF-4) and the Chemistry and Metallurgy Research (CMR) Building.

At 40,000 square feet in four wings, things are getting tight in PF-4. "The lack of space drives what we can do in that facility," said Mah. "We require guns, gates, guards, and other special capabilities to work with actinide materials; at a $10,000 per square foot replacement cost, these are expensive operations."

NMT Division Director Tim George also emphasized the importance of the Laboratory's actinide research facilities to the nation's nuclear mission.

"PF-4 and CMR remain the nation's only facilities capable of handling all isotopes and chemical forms of plutonium, as well as other actinides," George told review committee members. "I would say that operation of these two facilities, in the context of their age, and the scope and significance of activities conducted within them, may be one of the most challenging tasks in the Department of Energy complex."

photo by Mick Greenbank

Steve Yarbro (left), Tim George (center), and Rich Mah listen to a speaker during the opening session of the annual NMT Division review.

George called the successful operation of these two nuclear facilities a major accomplishment of the division for the past year. While PF-4 is the nation's newest plutonium research and development facility, it is more than twenty years old and is reaching the end of its design life. And at fifty years old, the CMR Building must be replaced within a decade.

Critical missions and a milestone

George told the review committee that while the pilot production of pits is the

Division Review

division's top priority, in the final analysis "stockpile surveillance and enhanced surveillance, or accelerated aging, may be the NMT missions most critical to the nation's security."

George emphasized the point by announcing a major milestone in enhanced surveillance that occurred the day before the review began: Researchers at Los Alamos have successfully developed a way to replicate how the stockpile ages by producing a "spiked" plutonium alloy that will age at an accelerated rate. This first-of-its-kind feat will allow researchers to observe the effects of plutonium aging in years instead of decades. (See cover story.)

Mah and George both stressed to the review committee the importance of Los Alamos maintaining a skilled work force. "We have the largest pool of nuclear scientists in the world," said George, "and we have to maintain that pool."

To meet that priority, critical skills have been identified and strategic hiring is under way in the division. One hundred new employees have been hired and at least another 100 are needed. One hitch is the lack of office space. "We want to hire additional staff," said George, "but it's very challenging; there's no place to put them."

In discussing the future, George talked about a two-year division initiative focusing on advanced nuclear fuels research to support a DOE-sponsored endeavor called the Generation IV Roadmap.

Generation IV, a DOE collaboration with nine other countries, will set out to identify nuclear power concepts and systems that can reach commercial viability by 2030. Generation IV will require extensive research in advance fuels in the form of oxides, nitrides, metals, and salts, and NMT's capabilities at the CMR Building and PF-4 will play a key role in research into these new fuel forms.

In its report, the review committee agreed that the advanced fuels trial program is an important priority for the division but recommended that the trial be lengthened to three years.

Labwide assessment due in August

The NMT Division report, as well as the individual reports of all other technical divisions at Los Alamos, will be rolled up into a Laboratory-wide report called the Science and Technology Assessment, which will be sent to the UC president's office in August. The Science and Technology Panel of the UC President's Council on the National Laboratories also assesses Lawrence Berkeley and Lawrence Livermore National Laboratories.

Anthony (Tony) Rollet chaired the external review committee for the second year. Rollet, of Carnegie Mellon University, is a former deputy leader of Los Alamos' Materials Science and Technology (MST) Division.

Other members of the review committee included Richard Bartsch, Texas Tech University; Darleane Hoffman, Lawrence Berkeley National Laboratory and former head of Los Alamos' Isotope and Nuclear Chemistry (INC) Division; Alexandra Navrotsky, University of California, Davis; Lee Peddicord, Texas A&M University; George Werkema, retired, DOE; and William Weston, Boeing Co., Rocketdyne Division.

Steve Yarbro, NMT deputy division leader for plutonium research and technology, was coordinator of this year's review. ■

—Meredith S. Coonley

Guest Editorial

Integrating research and development with production missions

Technology transfer between Savannah River and the national labs

Throughout its long history, the Savannah River Site (SRS) has benefited from close relationships with the national laboratories, not the least of which is a special relationship with Los Alamos, based on our complementary capabilities in tritium and plutonium. These partnerships are essential in enabling this key Department of Energy (DOE) site to fulfill its current and future missions.

Susan Wood

The SRS is a DOE industrial complex dedicated to stewardship of the environment, the enduring nuclear weapons stockpile, and strategic nuclear materials. The SRS processes and stores nuclear materials in support of national defense and U.S. nuclear nonproliferation efforts.

With its applied research and development (R&D) lab, the Savannah River Technology Center (SRTC), the site also develops and deploys technologies to improve the environment and treat nuclear and hazardous wastes left from the Cold War.

The site—with its five nuclear reactors (now shut down) and two chemical separations plants, plus numerous other production and waste-management facilities—was built in the 1950s to produce materials used in nuclear weapons, primarily tritium and plutonium-239.

The SRS complex covers about 310 square miles encompassing parts of three South Carolina counties along the Savannah River, on the South Carolina–Georgia border.

Science and technology at SRS

Science and technology (S&T) have always been important at SRS because they support plant operations, enhance environmental cleanup, reduce cost, enhance safety, and enable new missions.

The S&T for SRS needs may come to the site from SRTC, one of the national laboratories, or elsewhere. Whatever the origin, it typically is transmitted through SRTC, which then assumes responsibility for

PAR Pond is a man-made lake, constructed in 1958 as a cooling pond for the Savannah River Site's P and R reactors, hence the name. "RAP Lake" was also considered as a name, but the site's location near Augusta, Ga. (home of the Masters golf tournament), prompted site officials to choose the acronym PAR instead. It serves as a natural habitat for a variety of aquatic animals, making it a "living laboratory" for studying alligators, several species of fish, and migratory birds.

This editorial was contributed by Susan Wood, director of the Savannah River Technology Center.

photos courtesy of Savannah River Site

Guest Editorial

ongoing support; hence our slogan, "We Put Science to Work." It is essential that we work closely with the national laboratories to leverage and integrate our respective capabilities as well as to provide a seamless transition from a "lead lab" to a production site. Each mission area necessitates different partnerships and relationships tailored to its specific needs and the S&T strengths of respective laboratories. Optimizing such integration requires mutual respect of each other's capabilities and a willingness to share and team.

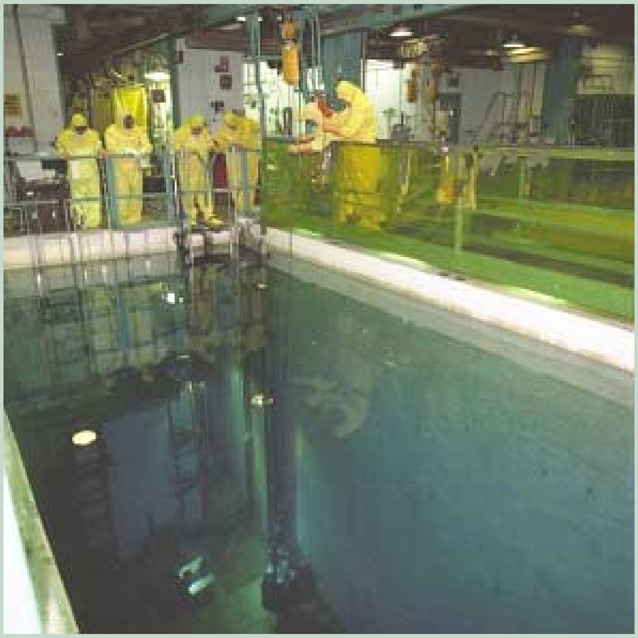
Tritium missions

Tritium, with a half-life of 12.5 years, must be replenished, and SRS is the nation's only facility for recycling and reloading tritium from nuclear weapons reservoirs returned from service. All tritium unloading, mixing, and loading is performed in a facility that went into operation in 1994, replacing older facilities that processed the nation's tritium for thirty-five years. A new facility is being built to extract tritium created in the Tennessee Valley Authority's light-water reactors.

SRS and Los Alamos have a fully integrated S&T roadmap, which supports both short- and long-term production mission objectives. Together, we represent the nation's core tritium capability. In addition, the Accelerator Production of Tritium (APT) team leveraged the joint core competencies in R&D and technology application to mutual benefit and success. This was an ideal role model for future work, which not only enabled rapid technology deployment, but broadened career opportunities as well.

Pacific Northwest National Laboratory (PNNL) also played a key role by performing experimental and modeling work to demonstrate tritium extraction from Tritium Producing Burnable Absorber Rods—or TPBARs.

An operator works on the Defense Waste Processing Facility's (DWPF) equipment through a shielded window with the aid of video monitors. Remote operations, coupled with five-foot-thick walls, are necessary to keep workers from being exposed to high levels of radiation produced by the waste going through the facility. DWPF is the largest radioactive waste glassification plant in the world. It is where high-level liquid nuclear waste currently stored at the Savannah River Site is converted into a solid glass form suitable for long-term storage and disposal. Since radioactive operations began in March 1996 at DWPF, more than 1,300 canisters of glassified waste have been poured. It is expected to take seventeen to twenty-five years to turn the entire site inventory of high-level waste into glass.



For more than three decades, the Receiving Basin for Offsite Fuels (RBOF) has been safely receiving and storing on-site fuels and fuels from domestic and foreign research reactor programs. Until 1988, it was routine for foreign researchers to return U.S.-origin spent fuel to this country. At the urging of the U.S. Department of State and the International Atomic Energy Agency, the Department of Energy renewed that policy in 1996. Plans are under way to deinventory RBOF, transferring spent fuel to Savannah River Site's L Area Disassembly Basin, a much larger facility. That basin was modified and received its first shipment of foreign spent fuel in January 1997.

Spent fuel

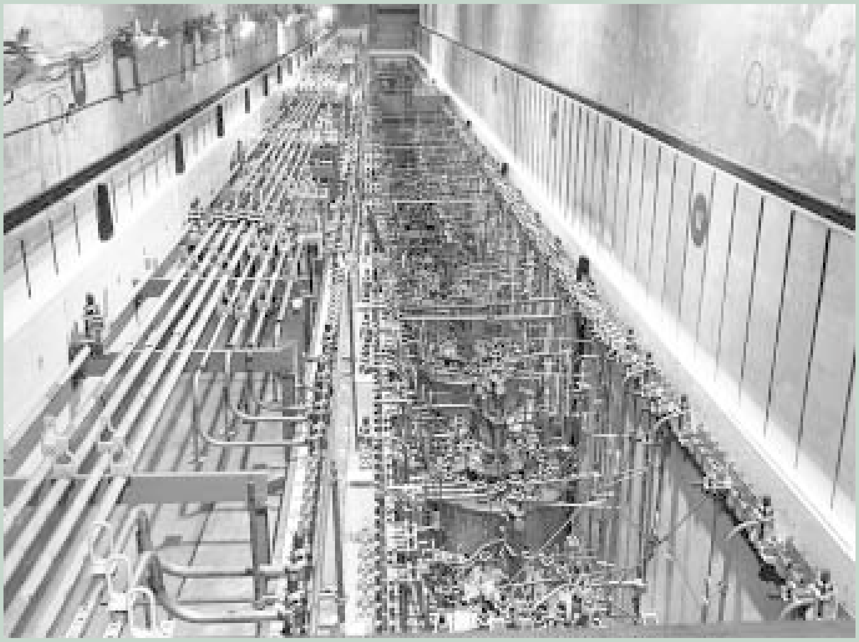
Spent fuel currently stored at SRS is from the site's production reactors and from domestic and foreign research reactor programs. All of this fuel is stored in water-filled concrete storage basins, which were intended originally for interim storage while spent fuel awaited processing in a chemical separations facility. In addition, studies are under way to find alternative technologies, such as dry cask storage, for the spent fuel.

SRS is the DOE's Center of Excellence for the dispositioning of aluminum clad fuel, an effort supported by Los Alamos.

Plutonium and other canyon missions

Savannah River Site's two primary separations facilities, called canyons, are located in F and H areas. F Canyon and H Canyon—together with the FB Line and HB Line, which are located atop the canyons—are where nuclear materials historically have been chemically recovered and purified.

Guest Editorial



Savannah River Site (SRS) has two primary separations facilities where nuclear materials historically have been chemically recovered and purified. Called F and H “canyons” for their long, narrow shapes, these large, remotely operated, heavily shielded facilities were constructed in the early 1950s to provide materials, initially plutonium-239, for the U.S. nuclear arsenal. As the chemical separations processes developed and matured, these canyons showed a versatility well beyond their original scope, processing a variety of materials, including uranium-235 and neptunium-237 (which, when irradiated, produced plutonium-238, which is used in power systems for the U.S. deep space exploration programs). In recent years, the canyons have been used to stabilize and manage legacy materials at SRS, including plutonium-bearing materials and highly enriched uranium. F Canyon completed its scheduled production mission in March 2002; H Canyon continues to operate.

In addition to defense materials, HB Line has produced plutonium-238 for Los Alamos, which NASA used for the 1997 Cassini mission.

F Canyon completed its PUREX processing mission in March 2002. PUREX is an extraction process in which fuel elements are dissolved in nitric acid and the uranium and plutonium are chemically separated out with solvents. H Canyon continues to stabilize and manage most of the remaining inventory of plutonium-bearing materials at SRS. In addition, DOE has determined that H Canyon should be used to convert a large quantity of weapons-usable highly enriched uranium (HEU) to low-enriched material suitable as fuel in commercial power reactors.

Additionally, the H Canyon role in plutonium stabilization will be expanded to include materials from dismantled weapons and surpluses from other DOE sites. SRS is also the announced location for the DOE’s plutonium pit disassembly and conversion (PDCF) and mixed-oxide (MOX) fuel fabrication facilities. Technology development for the plutonium immobilization facility, which has been suspended, involved a strong partnership with Lawrence Livermore National Laboratory, which had the technology lead.

Both the past and the future of SRS plutonium missions involve close interaction between Los Alamos and SRS. Traditionally, we have synergistically shared and used actinide chemistry and process knowledge.

The plutonium-238 mission was a joint program, which was transferred to Los Alamos in 1995. Furthermore, Los Alamos is the lead lab for the PDCF, but we have not achieved the level of integration in plutonium that has been accomplished with the tritium mission.

SRS has a vital role in plutonium management for DOE. In its support of SRS missions, SRTC has a vital role in plutonium research, development, and technology (RD&T), as does Los Alamos. I believe that improved teaming and integration of RD&T would provide benefits for the customer and the technical staff at both locations. Certainly, it would facilitate technology transfer and ongoing support to the production site.

Waste management and environmental restoration

Weapons material production created unusable byproducts, such as radioactive waste. About 38 million gallons of high-level radioactive liquid waste are stored in tanks at SRS. The Defense Waste Processing Facility (DWPF), which began operations in 1996, is processing the highly radioactive waste by bonding radioactive elements in borosilicate glass. Much of the volume in the tanks ultimately will be separated as relatively low-level radioactive salt solution, which is mixed with cement, ash, and furnace slag, and poured into permanent concrete monoliths for disposal at a facility called Saltstone.

A technician works inside a glovebox on the HB Line, located on top of H Canyon. HB Line was built in the early 1980s to support the production of plutonium-238, a power source for the nation's deep space exploration program. Decisions announced between December 1995 and October 1997 concluded that HB Line should be used to stabilize solutions stored in H Canyon. HB Line consists of three process lines. The Scrap Recovery Line is used to recycle legacy plutonium scrap (sometimes mixed with other radioactive materials) for purification and concentration to a solid form. The Neptunium-237/Plutonium-239 Oxide Line can produce solid oxide material from neptunium-237 or plutonium-239 nitrate solutions. (This line started operations for the first time in November 2001. The plutonium material is shipped to FB Line for storage and eventual disposition. The neptunium material will be shipped offsite for further processing.) The Plutonium-238 Oxide Line can produce plutonium-238 oxide from nitrate solutions; there is not a current mission for this line.

Construction began on the first high-level waste tanks at the Savannah River Site (SRS) in 1951, while the last waste tank was constructed in 1981. The waste tanks vary in size, from 750,000 gallons to 1.3 million gallons. There were fifty-one tanks originally constructed at SRS. However, in 1997 SRS closed the first two high-level waste tanks in the nation by filling them with a special grout mixture and concrete, bringing the number of waste tanks available to forty-nine. There are about 37 million gallons of waste stored in these tanks awaiting processing. The highly radioactive portion of the waste stored in the tanks will be sent to the Defense Waste Processing Facility, where it will be immobilized by converting the liquid waste into glass. The low-level portion of the waste material will be treated and stored on site in a special grout-cement mixture until its radioactive constituents decay to harmless levels.

Savannah River Site's working relationships with national laboratories in support of the high-level waste mission are many and varied. They include strong teaming with PNNL on vitrification and waste pretreatment, together with Oak Ridge National, Argonne National, and Idaho National Engineering and Environmental Laboratories. The key has been to identify the best capabilities and integrate them to support mission needs, assisted by the Tanks Focus Area (part of the Environmental Management R&D Program).

The integrated technology roadmap is, however, more near-term than the tritium model described earlier. Thus, while resources are best used and networking relationships are strengthened by this approach, it does not promote long-term partnerships.

Similar relationships are in place to support the mission to remediate the site's 515 inactive waste and groundwater units. Waste sites range in size from a few square feet to tens of acres and include basins, pits, piles, burial grounds, landfills, tanks, and associated groundwater contamination. While there are many common factors across SRS contamination sites that also extend to other parts of the DOE complex, there are also many site-specific factors that impact chosen remedies. Thus, rapid knowledge-sharing and technology reapplication skills are key to successful technology reuse at multiple sites.

In all of these activities, teaming with the national laboratories is part of everyday life at Savannah River. A continued strengthening of the special relationship between SRS and Los Alamos will be beneficial to all of us, as we jointly pursue our enduring missions. ■

Plutonium Futures 2003 conference speakers set

The next Plutonium Futures—The Science Conference will be held July 6–10, 2003 at the Albuquerque Marriott.

The conference addresses scientific and technical issues surrounding plutonium and other actinides and attempts to educate the public and students on these topics. The planning committee has already received a significant number of responses from scientists and researchers throughout the world who are eager to attend the 2003 conference.

The conference committee expects a very successful scientific and academic conference similar in format to the last conference in 2000. More than 400 international participants from sixty institutions and fifteen countries attended the July 2000 conference.

Next year's venue will feature speakers such as Pierre D'Hondt, director of Reactor Safety, Belgian Nuclear Research Center (SCK-CEN), who will speak about advances in mixed-oxide (MOX) fuel technology; and Roland Schenkel from the Institute for Transuranium Elements, who will speak about the recent highlights of actinide research at ITU.

Teresa Fryberger from the Department of Energy (DOE) Office of Science will discuss environmental aspects of plutonium and other actinides. Helen Caldicott, founder of Physicians for Social Responsibility, will be the banquet speaker. She will discuss medical implications of plutonium research.

Other guest speakers who have been invited but not yet confirmed include Margaret Chu, DOE's director of Civilian Radioactive Waste Management, and Nikolas Ponomorev-Stepnoi, vice president of the Russian Research Centre Kurchatov Institute.

The conference will kick off with a special tutorial for students on Sunday, July 6. The conference committee is encouraging student participation and the conference will pay travel expenses for students who present papers.

Monday, July 7, will feature the plenary speakers. The plenary lectures establish the motivational, historical, and scientific reasons for holding the conference. The following days will include presentations by technical experts and poster sessions. The banquet is scheduled for Wednesday evening, July 9.

Registration is $350 if received before June 5, 2003. After June 5, the cost is $450. For American Nuclear Society members, the cost is $300 for early registration and $400 after June 5, 2003. The second announcement and call for papers will be mailed in early August.

To register or express an interest for mailings, access the conference Web site at www.lanl.gov/pu2003. ■

Profile

Mary Neu is intrigued by actinides

Actinide chemistry is complicated, underexplored, and has room for important discoveries

Mary Neu

"It is human nature to believe that the phenomena we know are the only ones that exist, and whenever some chance discovery extends the limits of our knowledge, we are filled with amazement," Marie Curie wrote when she pondered the lack of knowledge about radioactivity in *Century Magazine*, January 1904. "We cannot become accustomed to the idea that we live in a world that is revealed to us only in a restricted portion of its manifestations … how numerous and varied may be the phenomena which we pass without a suspicion of their existence until the day when a fortunate hazard reveals them."

It was this intrigue that interested Mary Neu in actinide chemistry as a graduate student and later prompted her to come to Los Alamos. "Actinide chemistry," Neu says, "is very complicated and underexplored. There is much room for many important discoveries."

Neu performed her undergraduate work at the University of Alaska at Fairbanks, starting out as a geology major. She soon discovered that other physical sciences were also interesting to her and switched her major to inorganic chemistry and mathematics.

She completed her doctorate at the University of California–Berkeley with her dissertation, "Coordination Chemistry of Two Heavy Metals: Ligand Preferences in Lead Complexation, Toward the Development of Therapeutic Agents for Lead Poisoning; Plutonium Solubility and Speciation in the Environment."

Working on her doctorate, Neu conducted a wide range of synthetic inorganic chemistry and solution thermodynamic studies.

She conducted the lead chemistry on the UC Berkeley campus under the direction of Professor Ken Raymond and did plutonium chemistry at Lawrence Berkley and Lawrence Livermore National Laboratories under the direction of Professor Darleane Hoffman and in collaboration with Bob Silva, Heino Nitsche, and Richard Russo.

She completed her doctorate at the first Glenn Seaborg Institute established at Livermore in the early 1990s.

As a UC President's postdoctoral fellow, she came to Los Alamos in 1993 and worked with Dave Clark in a group that was then in the Inorganic and Nuclear Chemistry (INC) Division. Her early research here was on the synthesis and characterization of actinide carbonate species. Neu studied the processes and means that actinides form chemical bonds with other molecules.

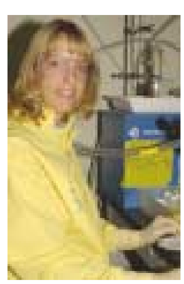
Currently, Neu is deputy group leader of the Actinide, Catalysis, and Separations Chemistry Group (C-SIC) and is conducting research in three general areas.

In the first research area, fundamental coordination chemistry, Neu is studying ligand preferences of actinides in different oxidation states and the resulting geometries of actinide compounds that may be used in new separations and processing technologies.

A second area of research is environmental speciation and behavior—studying and predicting the nature of contaminant plutonium. Neu's research, performed in collaboration with several colleagues at Los Alamos, helped identify the common oxide of plutonium(IV) as the chemical species that is prevalent in soils at Rocky Flats.

To determine how important and stable particular species are, Neu studies the

photos by Mick Greenbank



formation and thermodynamics of plutonium complexes of carbonate, hydroxide, chloride, and other ligands under environmental conditions. These studies, together with actinide-mineral interactions and geochemical calculations, support the development of predictive contaminant mobility models and new cleanup technologies.

Neu's third area of research is actinide interactions with microorganisms and microbial chelators—with the goal of using those microorganisms to stabilize or otherwise transform plutonium. For these research projects Neu works in close collaboration with colleagues in the Biosciences (B) Division, primarily Larry Hersman.

Her most exciting recent research results involve the reduction of plutonium(VI) and (V) by a common bacteria, *shewanella putrifaceans*. Although the exact mechanism is not well understood, these are the first results that indicate plutonium can be reduced through bacterial respiration to less environmentally mobile forms. Neu plans to further study this relationship and will submit a paper to the journal *Science*. She also has applied for Laboratory Directed Research and Development funds for the project.

An outcome of this research with bacteria is that she and her team have found that the toxicity of plutonium and uranium to microorganisms is generally less than that of some of the more common hazardous metals, such as zinc, nickel, and cadmium.

Her work brought her to Los Alamos because it is one of the few places in the country where she can research what she enjoys—fundamental actinide science.

She sees real difficulties in the future of actinide research and radiochemistry because there aren't many professors teaching these topics any more. The biggest challenge to actinide science, Neu believes, is that bureaucracy, old equipment, and aging facilities impede actinide research here as well as at other facilities.

Most of her work is done in the fifty-year-old Chemistry, Metallurgy, and Research (CMR) Building. Hope is on the horizon: A new facility is planned. Neu is enthusiastic about the CMR Replacement project and hopeful that research space will be included and improved in the new facility, which is scheduled to be built around 2010.

"There is a tremendous need for modern radiological facilities across the Department of Energy complex and especially at Los Alamos, where such facilities are essential to both our core missions and to our research excellence," Neu said.

She has a passion for actinides, and doesn't do it any differently than she did ten years ago. "I wanted to be safe ten years ago and I want to be safe now," Neu said. "I'm optimistic about the science and the incredible information we have yet to discover, but I'm also knowledgeable of the nontechnical challenges associated with actinide research." ■

—Kathy DeLucas

Award

The science behind "Eye of the Beholder"

"Eye of the Beholder," the photo on page 21, is an inside view of a vacuum chamber that will be used for laser-ablation, matrix-isolation studies of actinide metal atoms and ions with small gaseous molecules such as oxygen, nitrogen, carbon dioxide, and hydrogen.

The research is the postdoctoral project of Steve Willson of the Actinide Chemistry Research and Development Group (NMT-11) and is sponsored jointly by Kirk Veirs of NMT-11 and Joe Baiardo of the Nuclear Materials Science Group (NMT-16).

Inside the vacuum chamber, a small actinide metal target is supported by a post inserted into the port through which the camera is looking (the post has been removed for the photograph).

A neodymium:yttrium aluminum garnet—or Nd:YAG—laser beam passing through the port where Greenbank has digitally added an eye is focused onto the surface of this metal target.

The resulting laser-induced plasma of metal atoms and ions are co-deposited with neon or argon and a small amount of reactant gas onto the mirrored copper surface visible in the center of the photograph. This surface is cooled to 6 Kelvins (six degrees above absolute zero) by a closed-cycle helium refrigerator.

The resulting thin film contains the reaction products of the metal atoms and ions with the reactant gas frozen into the inert gas matrix. The reaction products are detected using infrared spectroscopy, which results in a series of vibrational bands.

Precise identification of the chemical formula of the reaction products is obtained by repeating the experiment with the same reactant gas containing a different mix of isotopes, which results in the vibrational bands shifting in predictable ways.

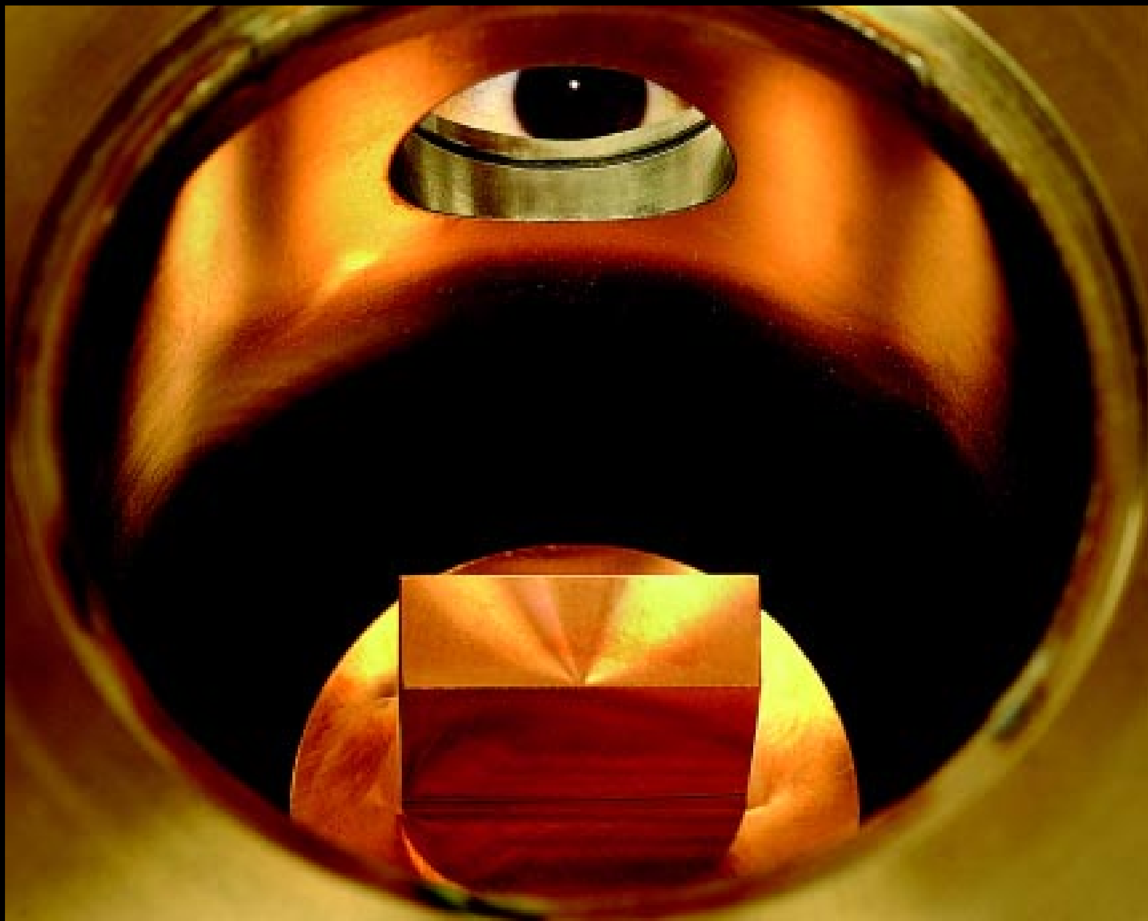
The chemical behavior of these reaction products are further studied by warming the matrix to a still chilly 10 to 35 K elvins, by photolysis of the products with ultraviolet light, or both.

Willson expects the system to be online this summer in the Plutonium Facility (PF-4), where it will be used to experimentally probe some of the simple reaction chemistry of actinide atoms with common atmospheric constituents. He designed the apparatus based on his graduate work with Lester Andrews at the University of Virginia and adapted it for safe operation with actinides and optimal use of the available space.

He anticipates that his research will be valuable for the exploration of some of the underlying processes that occur in larger systems. The data collected will provide a spectroscopic catalog that he and his sponsors hope will simplify the identification of actinide compounds in larger systems, with application for corrosion studies of actinide-containing components.

The components were fabricated by Art Montoya of the Chemistry Facilities Management Group (C-FM) in the TA-48 machine shop and welded by Johnny Quintana of the Weapons Materials and Manufacturing Group (ESA-WMM) at the main shop. During the design stage, Willson received assistance from John Morris of NMT-11.

Several adjustments made during the fabrication stage at the suggestion of Montoya improved the design and have been instrumental in an invention disclosure filed on one of the fabricated components. ■



This photo, called “Eye of the Beholder,” by Mick Greenbank won third place in the Scientific/Industrial category at the Imaging Professionals of the Southwest (IPSW) Conference 2002. Greenbank and Joe Riedel, both with the Nuclear Materials Information Management Group (NMT-3), each came away with several awards from the conference, held in Albuquerque in April. Besides his award for “Eye,” Greenbank received first place in the Commercial/Industrial category and honorable mention in the Special category. Riedel received both first place and honorable mention in the Special category.