RADIOCHEMICAL PROCESSING LABORATORY

A NATIONAL ASSET WITH MULTIPLE MISSIONS

The Radiochemical Processing Laboratory has had different names and operators in its lifetime. We acknowledge this history, but for simplicity refer to the building as RPL and consider its operator to be Pacific Northwest National Laboratory. Here is a summary of name and operator changes:

Name Changes

1953 (construction complete) Applied Chemistry Laboratory, or the 325 Building

1991 Applied Chemistry Laboratory

1997 Radiochemical Processing Laboratory

Operating Contractors

1953 General Electric

1965 Battelle Northwest Laboratories (contract to operate Hanford Laboratories)

1970 Westinghouse and Battelle Northwest Laboratories share operation of 325 Building

1987 Pacific Northwest Laboratory operates the 325 Building

1995 Pacific Northwest Laboratory becomes a national laboratory, Pacific Northwest National Laboratory

1995 to present, Pacific Northwest National Laboratory

Contents

4 Delivering Solutions for Multiple Missions Since 1953

8 Research for Nuclear Energy

- 8 Ensuring Reactor Safety
- 9 Enabling Isotopic Power Generation

10 Research for Health

- 10 Fighting Cancer

11 Research for Environmental Cleanup

- 11 Targeting Tank Waste Cleanup for the Vitrification Plant
- 12 Characterizing Sludge from Nuclear Fuel Storage for Safe Cleanup and Future Disposal
- 13 Collaborating to Safely Reclaim and Stabilize Plutonium and Decontaminate the Plutonium Finishing Plant
- 14 Analyzing Minuscule Sample Helps Identify Cause of Waste Isolation Pilot Plant Explosion

15 Research for Nuclear Nonproliferation

- 15 Analyzing Particulate Air Samples to Look for Illicit Nuclear Testing
- 16 Reducing Proliferation Risk by Testing Alternative Fuel for Civilian and Test Reactors
- 17 Producing Sealed Sources to Test Nonproliferation Instruments and Processes
- 18 Aiding Nuclear Forensics Work at a New Test Bed

19 RPL: an Enduring Asset for the Nation

Delivering Solutions for Multiple Missions Since 1953

No single mission defines the importance of the Radiochemical Processing Laboratory in its more than 60 years of service to the Nation. This Hazard Category II facility, located in southeastern Washington State on the edge of the Hanford Site, has housed a collection of missions, projects, and the world-class research and operations staff that cements its place in the nuclear history of the United States. This work continues.

The Hanford Site played a pivotal role in the Manhattan Project, producing the plutonium for the atomic bomb that helped end the war with Japan in 1945. Work performed for the defense mission at Hanford built the foundation for breakthroughs in nuclear technology and the peaceful uses of nuclear energy.

Since then, the Radiochemical Processing Laboratory, or RPL, has supported research promoting reactor safety, isolating isotopes to cure cancer, understanding waste treatment to provide solutions to environmental cleanup questions, and advancing nuclear nonproliferation.

In the beginning

RPL was constructed between 1949 and 1953 in the 300 Area of the Hanford Site. Its footprint was 116,000 square feet and its main purpose was to evaluate, develop, and integrate technologies and solve problems with radiological materials.

RPL was originally designed to provide production support and process improvements for the Reduction-Oxidation plant (REDOX), improvements for the uranium metal recovery process (especially handling wastes and acids), and studies of separations waste treatment aimed at developing techniques to reduce highly radioactive wastes to lower activity levels.

RPL Accomplishments

- Developing and proving materials to enable Fast Flux Testing Facility production and operations
- Developing, fabricating, and measuring reactor dosimetry capsules to verify reactor conditions
- Developing and conducting unique isotope separations for industrial, medical, and space missions
- Improving Stirling Radioisotope Generators
- Developing methods for life-saving yttrium-90 production and enabling process commercialization
- Developing and testing processes for waste characterization and treatment of highly radioactive tank waste
- Characterizing and testing K-Basin sludge for safe removal and storage
- Characterizing Waste Isolation Pilot Plant sample to determine accident progression and enable repository restart
- Operating the only certified radionuclide laboratory in the United States for the Comprehensive Nuclear-Test-Ban Treaty Organization
- Demonstrating low-enriched uranium-molybdenum alloy fuel to enable research reactor fuel conversion
- Producing robust sealed nuclear material sources to test nonproliferation instruments and processes

1953
Radiochemical Processing Laboratory construction complete

1960
High Level Radiochemistry Facility added isotope separation for NASA and medical research

1963
Shielded Analytical Laboratory added

1951 1953 1955 1957 1959 1961 1963 1965 1967

Other important early missions included production development for radioactive lanthanum (a tracer gas in non-nuclear test explosions), technical support to the bismuth phosphate process, support studies for tritium production, and basic investigations of plutonium chemistry. Other projects supported within the RPL included development of the process for reclamation of uranium and plutonium by extraction (RECUPLEX), plutonium-uranium extraction (PUREX), and the Plutonium Recovery Facility processes.

Expansion

In the early 1960s, two wings were added to make RPL the largest of Hanford Site's laboratories. The High Level Radiochemistry Facility (HLRF) was completed in 1960 and enabled work on isotope separations including 14 million curies of strontium-90, cesium-137, curium-244, americium-241, and promethium-147 (for betavoltaic nuclear batteries for cardiac pacemakers and the artificial heart). In work for the National Aeronautics and Space Administration, plutonium-238 was recovered from special neptunium-237-irradiated targets.

In 1963, the Shielded Analytical Laboratory (SAL) was completed. This wing added six hot cells that minimized worker exposure and enabled the preparation of high-activity samples for analysis.

In the 1970s, RPL focused on supporting the Fast Flux Test Facility (FFTF), a first-of-a-kind liquid metal breeder reactor. Staff members conducted foundational research into materials behavior to characterize production capabilities.

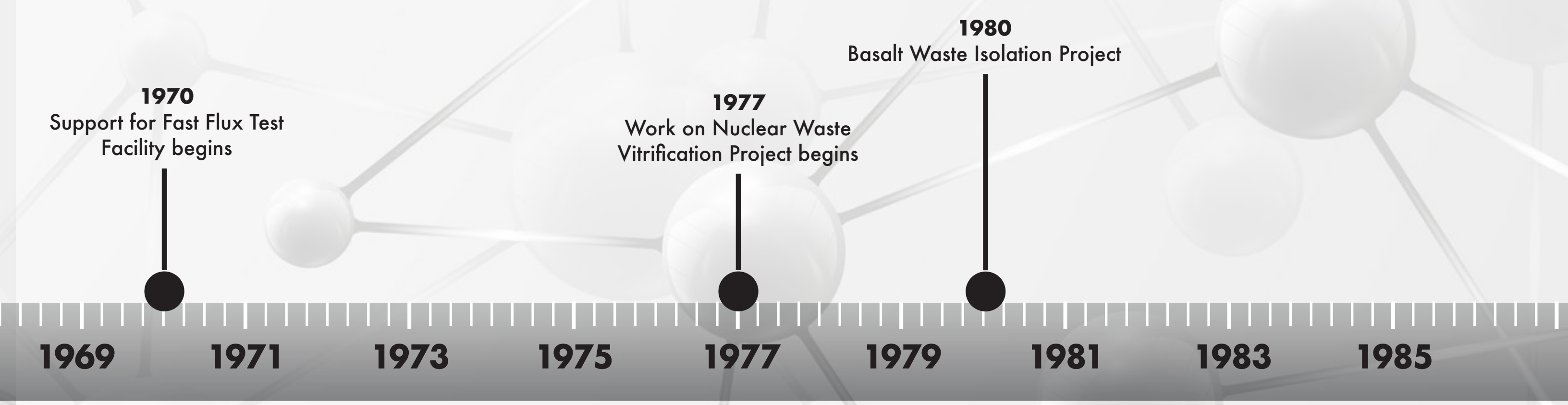
Turning to Hanford Site Cleanup

As Hanford Site waste tanks began reaching capacity in the 1960s, concern over waste migration was growing, and researchers started investigating methods of vitrifying (solidifying into glass waste form) the high-level waste. From 1977 to 1980, researchers used the RPL to conduct studies for the U.S. Department of Energy (DOE)'s Nuclear Waste Vitrification Project. This project demonstrated the ability of RPL and its staff to process waste beyond laboratory scale. The objective was to vitrify high-level liquid waste from light-water reactor spent fuel. The campaign processed 2,350 kg of uranium and 17.7 kg of plutonium.

In the 1980s, RPL supported the Basalt Waste Isolation Project as part of its study for a potential commercial nuclear waste repository at the Hanford Site. Hydrothermal tests of radioactive waste, necessary for the study, were conducted in RPL's hot cells.

In 1992, the facility and staff supported the Hanford Waste Vitrification Plant by creating a waste treatment flowsheet; testing characterization and treatment processes; and studying the behavior of the organic complexant, Cr^{3+}, and ferrocyanide. Work on the Waste Treatment Plant continues today.

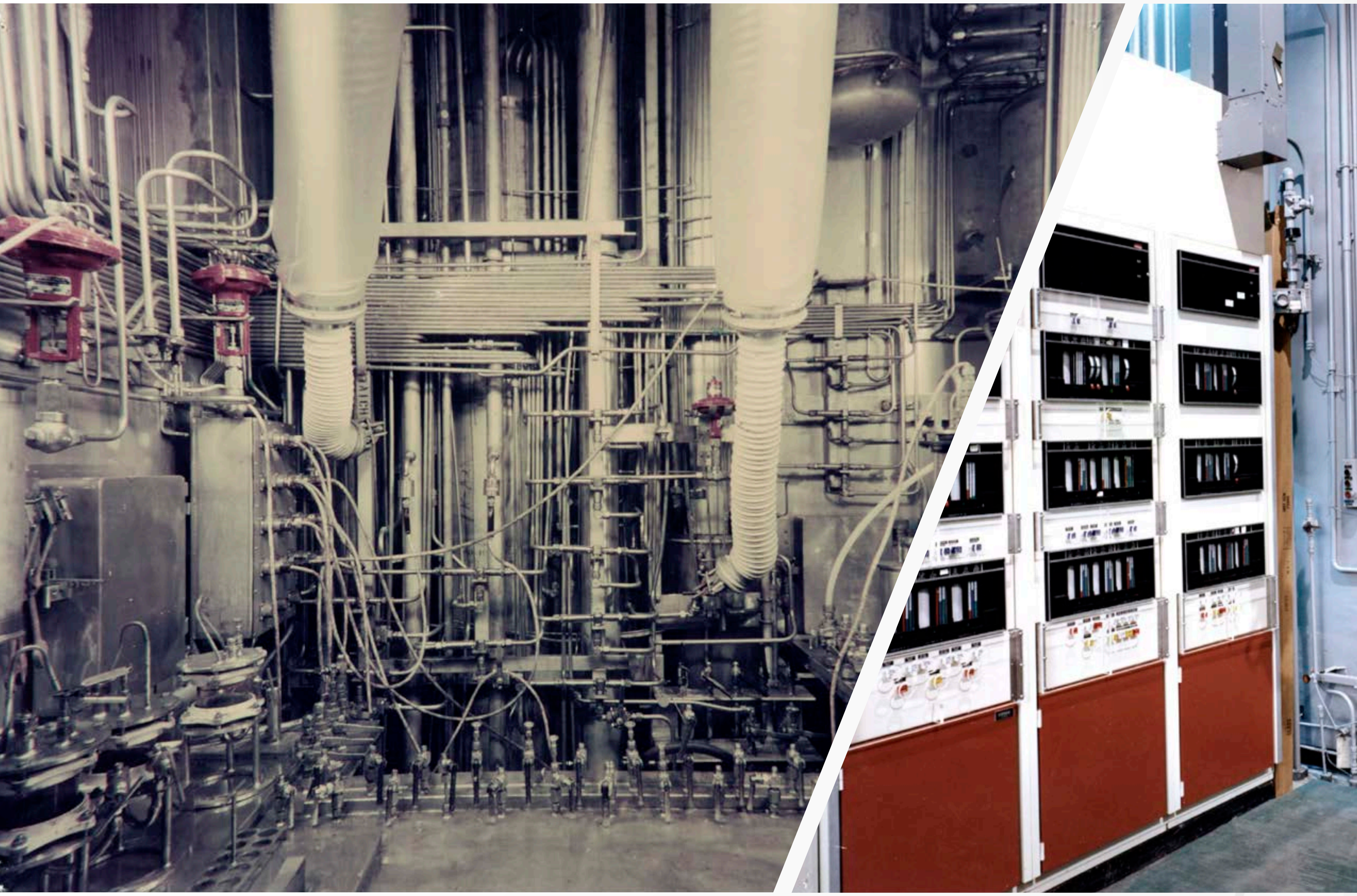
K Basins support began in 1993 by developing the sludge disposition strategy and characterizing uranium metal and sludge.



Diverse Missions

Hanford Site cleanup activities set in motion the relocation of work from the other 300 Area buildings to RPL and PNNL's new Physical Sciences Facilities, completed in 2010. Updates to RPL facilities, improvements in infrastructure, and investments in new instruments set the stage for a renewed research and development focus in nuclear energy, environmental research, and programs to support nuclear nonproliferation. Some of the newer missions are described in this document.

- RPL is the only certified radionuclide laboratory in the United States to analyze the samples collected from the Comprehensive Nuclear-Test-Ban Treaty Organization's International Monitoring System.
- RPL conducts research to characterize low-enriched uranium fuel for research reactor fuel work that supports DOE's National Nuclear Security Administration (NNSA) Office of Material Management and Minimization nonproliferation mission.



- **1990** Reactor dosimetry work
- **1992** Hanford Waste Vitrification Project support
- **1993 – present** K Basin support
- **1996** U.S. patent for yttrium-90 production process
- **2000 – present** Stabilizing plutonium and decontaminating the Plutonium Finishing Plant
- **2001** Federal Laboratory Consortium (FLC) technology transfer award for yttrium-90 production

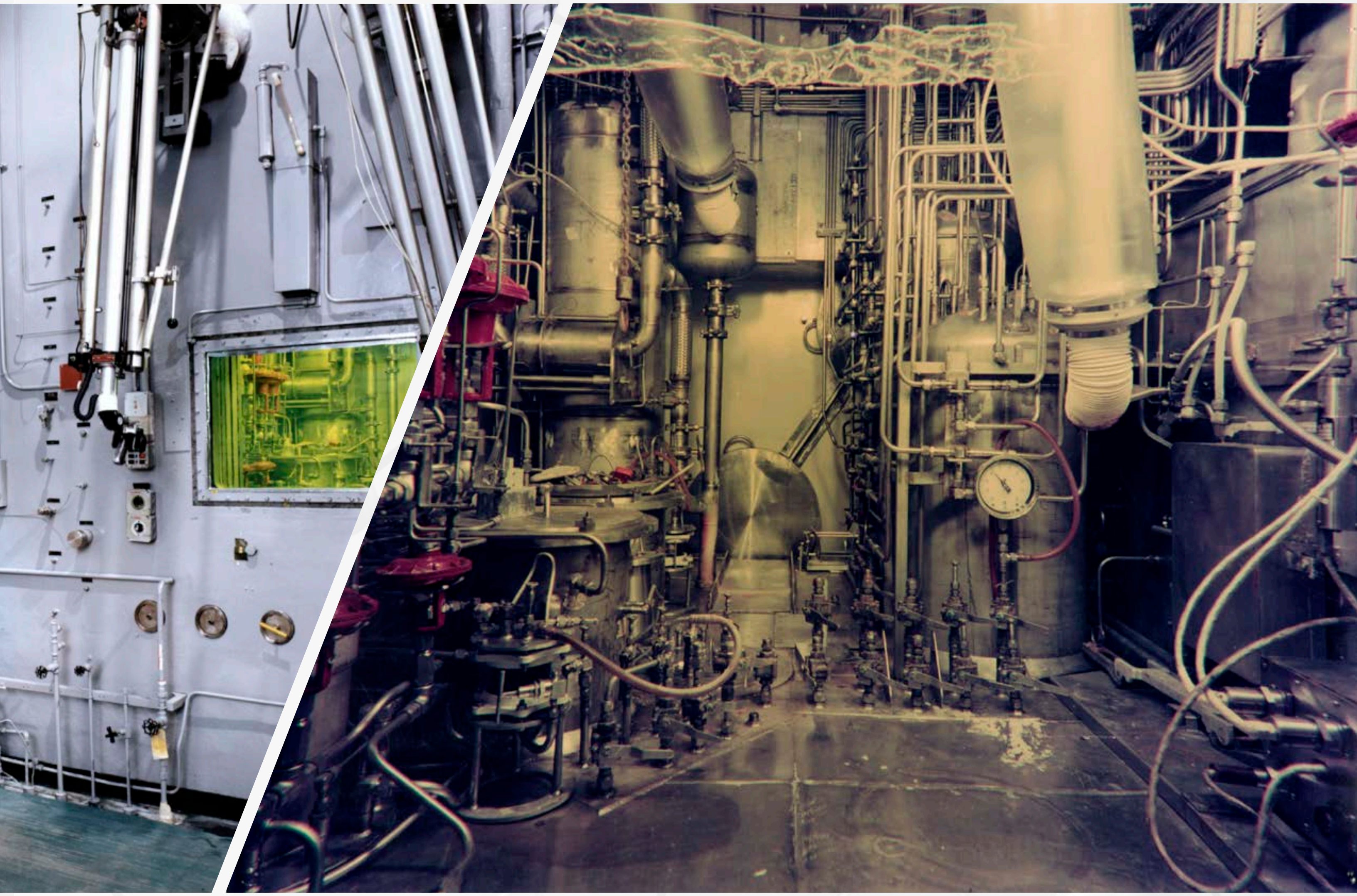
1987 1989 1991 1993 1995 1997 1999 2001 2003

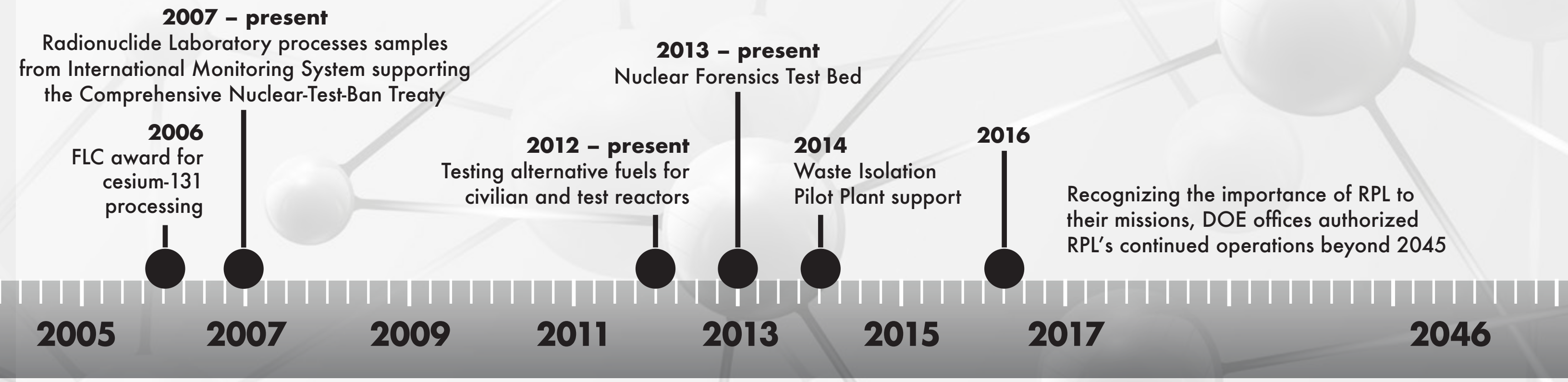
- RPL staff and facilities supported the Waste Isolation Pilot Plant (WIPP) Assessment Team in its investigation of an accident in 2014.
- RPL prepares plutonium sealed sources for use in radiation detection testing.
- RPL's plutonium oxide project is working to identify and validate nuclear forensics signatures associated with plutonium production.

RPL has hot cells, gloveboxes, and radiological fume hoods, which means a wide range of activities can be carried out in this single building.

Because research and development (R&D) are RPL's mission, the facility operations are flexible, enabling R&D to modify processes and get projects under way and accomplished quicker than in a facility with a single mission focus.

The following sections describe some of RPL's newer projects and their impact on advances in nuclear energy, health, environmental cleanup, and nuclear nonproliferation.





Research for Nuclear Energy

Ensuring Reactor Safety

One of the most challenging aspects of nuclear energy is providing the scientific proof that a nuclear reactor is safe to operate. Reactor dosimetry allows researchers to verify that calculations of neutron fluence and radiation damage to reactor materials are reliable. Researchers at RPL developed this highly specialized capability in 1990.

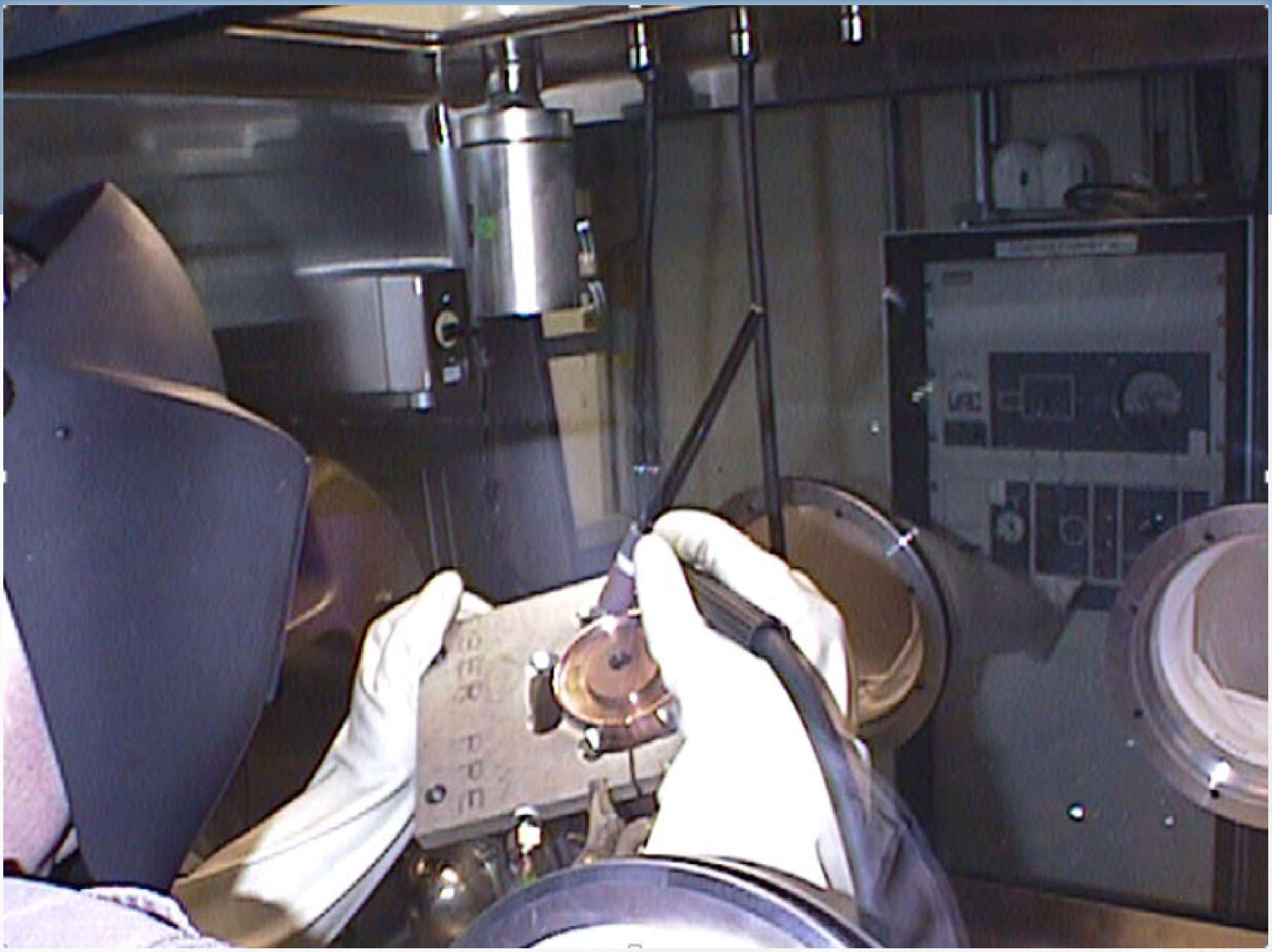
Dosimetry monitor capsules are custom designed and constructed in RPL. They are built with 14 or more pure and well-characterized materials, based on the client's reactor environment. Using *in situ* activation and melt wire measurements, the capsules indicate the temperature and radiation exposure at various locations inside the reactor and at the pressure vessel. RPL's small neutron flux monitor capsules are especially effective because they can include the following diverse materials that can simultaneously measure multiple activity reaction products:

- Titanium
- Manganese
- Scandium
- Iron
- Nickel
- Boron
- Lithium
- Cobalt
- Copper
- Gold
- Lutetium
- Beryllium
- Aluminum
- Various isotopes of plutonium, uranium, and neptunium.

The capsules can sustain multi-year deployments in high-temperature, high-flux neutron fields—including reactor pressure vessels. Multiple capsules can be used in different locations inside the reactor. Measurements also can be made directly from reactor materials that are sampled during outages or after removal from the reactor in a process referred to as "retrospective reactor dosimetry."

Once removed, the now highly radioactive dosimetry monitor capsules are returned to the RPL. Upon analysis in this Category II facility, the activation of the materials in the capsule reveals the status of a nuclear reactor, based on the neutron fluence, displacement of atoms, and gas production. These measurements can help determine if the pressure vessel is in danger of swelling or brittleness.

The dosimetry measurements taken in RPL primarily serve as an external verification of calculations, such as those performed by the utility that operates a nuclear power reactor or by organizations operating research reactors. RPL's reactor dosimetry clients include laboratories; universities; and commercial entities in Europe, Asia, and across the United States. The U.S. Nuclear Regulatory Commission relies upon RPL to verify calculations of the neutron fluence and radiation damage, which ascertain an operating reactor pressure vessel's lifetime.



Enabling Isotopic Power Generation

The isotopic heat source was a piece of plutonium-238 the size of a ping pong ball, which was used to drive a Stirling cycle: plutonium-238 heats helium to drive a piston to generate electricity. The goal was to discover a safe, efficient way to power missions in deep space.

Working with the NASA Glenn Research Center, DOE, Los Alamos National Laboratory, and the now-closed Mound Laboratory in Ohio, PNNL's role in the Stirling Radioisotope Generator was to couple the plutonium-238 to the generator components so it would run.

RPL was one of the few places with the capacity to accept the quantity of fissionable material that was used in the generator. The team in RPL received the plutonium-238 from external partners.

The collaboration within PNNL—from nuclear and engineering expertise to scientists in the Environmental Molecular Sciences Laboratory, a DOE user facility—combined with RPL's capabilities enabled progress on the Stirling project. First designs did not have the power-generation durability, but subsequent designs solved the problem and RPL was home to extensive isotope power testing.

Research for Health

Fighting Cancer

With RPL's nuclear science capabilities, researchers have developed a number of patented methods for making highly pure medical isotopes vital for cancer research, such as yttrium-90, actinium-225, radium-223, bismuth-212, lead-212, zirconium-89, and astatine-211.

In the 1990s, most medically available yttrium-90 contained traces of contaminants that undermined its effectiveness in targeting tumors, especially non-Hodgkin's lymphoma (a blood cancer) and liver cancer. RPL researchers developed a process of separating highly pure yttrium-90 from purified strontium-90.

RPL's yttrium-90 production process received an international patent in 1993, a U.S. patent in 1996, and a Federal Laboratory Consortium (FLC) technology transfer award in 2001 after it was privatized to PerkinElmer/NEN Life Sciences for ongoing production, shipping, marketing, and sales. This further enabled the widespread application and use of yttrium-90 in cancer treatment.

Medical isotope production and applications research has been successful in:

- Developing a separation process to make brachytherapy cancer treatment seeds using the radioactive isotope cesium-131. Tiny and thin, the seeds are implanted in the tumor to quickly kill the cancer. In partnership with IsoRay Medical Inc., the cesium-131 process was patented in 2000 and received an FLC award in 2006.
- Creating "radiogel" products that offer people with inoperable tumors a better chance for treatment. Radiogels allow the insoluble yttrium-90 to be injected to precise locations in the body, where it works directly on the cancer with minimal radiation exposure to healthy organs and tissues. Once the yttrium-90 decays, the radiogels dissolve and disappear. This process was licensed to Advanced Medical Isotope Corp. in 2011 and received an FLC award in 2012.
- Automating the radiochemical processing of isotopes using astatine-211, a short-lived alpha-emitting isotope. This research partnership with the University of Washington, from a DOE Isotope Program research grant, is developing an active solvent extraction process that results in more consistent quality. It has entered clinical trials.

Research for Environmental Cleanup

At Hanford alone, 56 million gallons of waste from plutonium production during World War II and the Cold War was stored in 177 aging underground tanks, and of these tanks, more than 60 have leaked. The waste contaminated the subsurface and threatens the nearby Columbia River. The Hanford Tank Waste Treatment and Immobilization Plant, also known as the Vitrification Plant, is being constructed to deal with this waste. When complete, the plant will pretreat the waste, blend it with glass-forming materials, heat it to 2,100°F (1,149°C), and pour the molten material into stainless steel canisters to cool and solidify. In its vitrified (glass) form, the waste will be stable and impervious to the environment, and its radioactivity will safely dissipate over hundreds of years.

Targeting Tank Waste Cleanup for the Vitrification Plant

For more than half its existence, RPL has supported R&D that targets the cleanup of wastes from the defense mission through vitrification. Studies began in 1977 with R&D and demonstrations for the DOE's Nuclear Waste Vitrification Project.

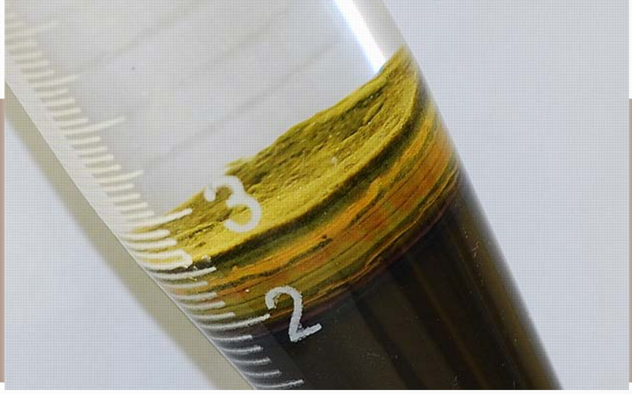
In 1992, research began in RPL to support the processes planned for the Vitrification Plant. Capabilities in tank waste chemistry (understanding chemical kinetics and thermodynamics, testing of actual waste, and developing simulants), fluid dynamics and scaling, waste forms (including glass phase stability) have set the stage for RPL to have an important role in treating and stabilizing the tank waste.

In the next 20 years, RPL would house first-of-a-kind demonstrations for all pretreatment processes for the Waste Treatment and Vitrification Plant: filtration, evaporation, ion exchange, and precipitation. RPL was at the center of PNNL's role, focusing the staff, equipment, and facilities to demonstrate caustic leaching, oxidative leaching, actinide precipitation, ion-exchange for removal of radionuclides, and crossflow filtration.

A critical tank waste safety issue, flammable gas generation within tanks, was resolved at RPL through innovative gas generation rate experiments that enabled continued safe Hanford Tank Farm operations.

Work at RPL has proven that pretreatment processes would work and also aided in developing a more economical resin for cesium removal and demonstrated its performance. The new resin was an order of magnitude cheaper than the previously tested resins.

RPL's work supporting waste treatment at Hanford continues today with the development of the Hanford Waste Treatment Test Platform. The test platform is designed to demonstrate the processes and potential alternatives for the Direct Feed Low Activity Waste (DFLAW) flowsheet. DFLAW is proposed by DOE to accelerate the treatment of the liquid fraction of the Hanford tank waste to take advantage of the readiness of the LAW facility to start operations. PNNL is installing all of the critical unit operations associated with the DFLAW flowsheet into the RPL so that demonstration of this flowsheet can be performed with actual waste that was recently transferred to RPL from the Hanford Tank Farms.



Characterizing Sludge from Nuclear Fuel Storage for Safe Cleanup and Future Disposal

When the N Reactor at the Hanford Site ceased operation in the late 1980s, its fuel was removed and stored in the K East and K West fuel storage basins. In storage underwater, some of the fuel rods and fuel rod segments began to deteriorate. When the fuel was removed, sludge from the deterioration remained. Constructed in the 1950s, the K Basins were used beyond their expected mission life. Removal of the sludge would help protect the nearby Columbia River. However, safe removal of the 47 cubic yards of sludge left in the bottom of the K Basins was predicated on answers to some key questions:

- Did the sludge contain uranium metal particles from the fuel?
- If so, how much uranium metal, and how big were the particles?
- If uranium metal was present, how could it be handled safely in moving the sludge from the basins and, ultimately, to permanent disposal?

Uranium metal reacts with water in the sludge to produce flammable hydrogen gas and heat. Too much uranium metal—especially if finely particulate—could react, rapidly heating water and leading to a steam explosion. Even if the reaction proceeded slowly, hydrogen could accumulate to dangerous levels. The contractor was particularly concerned about the containers used to transport the sludge from the K Basins away from the Columbia River to Hanford's T Plant, the containers for extended storage at T Plant, and the containers for transport of treated waste from T Plant to permanent disposal.

In the early 1990s, experts could not agree on the behavior of the uranium in the sludge. Extensive characterization work performed by staff members at RPL showed an interesting phenomenon: a swelling pocket of gas forming at the base of the water-settled sludge solids. Results from lancing the gas pocket, followed by collecting and analyzing the gas, showed not only hydrogen from the uranium-water reaction but krypton and xenon fission product gases that could only have arisen from irradiated uranium metal. More than 30 subsequent carefully controlled tests at the RPL using actual sludge samples, with and without added crushed uranium metal fuel, established that the uranium particles reacted in the sludge at rates entirely consistent with rates known in the technical literature and that uranium metal particle size distributions could be determined.

The sludge characterization work included uranium metal concentration measurements that would allow design of safe sludge transport, storage apparatus, and procedures at T Plant. RPL research staff also investigated several alternative methods to process the sludge and remove the hydrogen hazard to make a waste form acceptable for disposal. RPL research staff collaborated with the Hanford contractors and with outside entities to provide both chemical and physical sludge simulants to test sludge handling, storage, and process alternatives and parameters. Testing at RPL provided the data that allowed the sludge to be consolidated by K Basin operators into six storage containers in the K West Basin and afforded subsequent decontamination and demolition of the K East Basin.

Research performed at RPL provided information to help triage the problems and provide alternatives that will eventually lead to the completion of the decontamination and demolition of these Cold-War-era fuel storage basins, safe interim storage of the sludge at T Plant, and ultimate permanent off-site disposal.

Collaborating to Safely Reclaim and Stabilize Plutonium and Decontaminate the Plutonium Finishing Plant

After decades producing multiple forms of plutonium for defense and nuclear fuels, the Hanford Site's Plutonium Finishing Plant (PFP) was due to be cleaned up and demolished. This high-risk transition process posed a series of complex challenges that required the nationally unique capabilities found just a few miles away in RPL.

Starting in 2000, PNNL staff worked side-by-side with Hanford Site contractors to research, develop, and implement processes to safely reclaim plutonium, stabilize it for long-term storage, and decontaminate multiple facilities within the PFP—including some that had started operations in 1949.

RPL research staff expertise and equipment analyzed and identified waste materials and potential chemical reactions in the decontamination processes and the stabilization of the Plutonium Reclamation Facility of the PFP. Some of the chemical reactions evaluated included the following:

- Chemicals planned for use in decontaminating plutonium process gloveboxes were found to be thermally unstable. These chemicals would have led to self-sustainable reactions that would have over-pressurized waste drums stored in the summer sun. PNNL and PFP worked to develop safe treatments for the decontamination chemicals that afforded safe storage and disposal.
- Glycerin, a common decontaminating agent in the nuclear industry, was found to react with nitric acid and nitrate salt remnants on the floor of the Plutonium Reclamation Facility during one phase of cleanup. PNNL staff at RPL analyzed the chemical residue from the reaction and found ways to stabilize it. The contractor then repackaged several important waste drums for disposal.

During the Plutonium Stabilization and De-inventory projects from 2000 to 2003, PNNL developed and supported technology for:

- Treatments to convert the plutonium-oxide-bearing polystyrene cubes into stable oxide forms for long-term storage.
- Treatments to stabilize plutonium-bearing solutions of widely varied composition as plutonium oxide.
- Treatments and assay methods for solid chloride-bearing plutonium scrap.
- Analyses of moisture in the stabilized oxide.

In this case, success means elimination. PFP is being torn down with substantial completion expected by the end of 2017. The close and trusting collaboration of scientists and engineers at RPL with their PFP colleagues has been key to the progress made on these many fronts.

From 2001 to 2003, RPL supported the rapid conversion to oxalic acid precipitation process to help meet the Defense Nuclear Facilities Safety Board's July 2002 milestone for plutonium solution processing. This work achieved a multi-million-dollar cost decrease, 14-month schedule recovery, significant reduction in potential personnel dose, and a two- to three-fold reduction in the final number of 3013 canisters requiring storage from the solution inventory.

The supporting process improvements for thermal stabilization of high-chloride scrap inventory items included RPL contributions in:

- Prompt gamma analysis method development to identify chlorine and other elements in plutonium scrap items
- Design of wash system apparatus, process optimization, kinetics/efficiencies, and residual chloride measurement
- Operational testing of prototype furnace, selection/testing of off-gas treatment methods/apparatus, materials performance tests, and chloride material balance
- Development of technical basis arguments in collaboration with Rocky Flats Environmental Technology Site, Savannah River Site, DOE Albuquerque Operations Office, DOE Richland Office, and PFP to allow lower temperature (at 750°C) thermal stabilization.

Analyzing Minuscule Sample Helps Identify Cause of Waste Isolation Pilot Plant Explosion

In February 2014, PNNL was among the five national laboratories assembled to investigate the explosion of a nuclear waste storage drum deep underground at the WIPP in New Mexico. WIPP stores drums containing radioactive waste removed from former World War II and Cold War nuclear weapons sites around the nation.

The explosion spewed radioactive residue throughout the storage area. Further complicating matters, the drum was in the middle of a 100-by-16-yard room where drums are stacked in 16-foot-high rows. To collect the samples needed to determine the cause of the explosion, WIPP workers sent a robot out along a steel beam with a long pole to swab the lip of the drum.

A mere 0.0072 grams of material was sent to PNNL for analysis and subsequent thermal reactivity studies. Adding to the challenge of the minute sample size was a requirement that all analyses needed to be admissible in a court of law. Nonetheless, a minute sample was enough for the RPL research team to determine the cause of the accident and help prevent a recurrence of a national nuclear emergency.

Using the assemblage of its tools and optical, organic, inorganic, radiological, gamma, alpha, and radionuclide analysis capabilities, RPL staff demonstrated that the explosion had been an unforeseen chemical reaction with the organic, wheat-chaff-based cat litter used to absorb liquids in the sealed drums.

The information RPL provided was used to help identify a recovery pathway and packaging needs for similar drums. WIPP reopened in December 2016. The WIPP Technical Assessment Team, including 10 PNNL staff members, received the DOE Secretary of Energy's Achievement Award for their technical leadership and exemplary collaboration.

Applying a Suite of Tools to Analyze the WIPP Sample

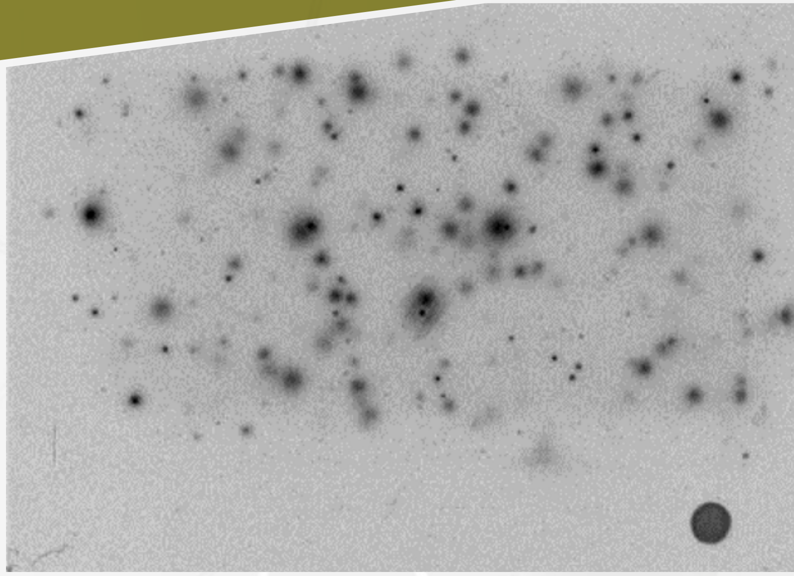
RPL already housed a robust radiochemical analytical capability, including gamma energy analysis, actinide measurement by alpha spectrometry with inductively coupled plasma mass spectrometry (ICP-MS), ICP-MS for radioactive analysis, infrared microscopy, optical microscopy, powder X-ray diffraction, thermogravimetric and differential thermal analysis, accelerated rate calorimetry, and radioactive material handling systems.

However, determining the cause of the WIPP drum explosion required additional analytical capability. The RPL's flexible operations enabled the research team to bring these essential tools online within 30 days of project activation:

- Raman microscopy
- Attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy

- Micro-X-ray fluorescence
- Scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS)
- Fluorescent microscopy
- Solid phase microextraction gas chromatography mass spectrometry (SPME-GC–MS)
- Nuclear magnetic resonance (NMR)
- Gas chromatography mass spectrometry (GC-MS).

Research for Nuclear Nonproliferation



Analyzing Particulate Air Samples to Look for Illicit Nuclear Testing

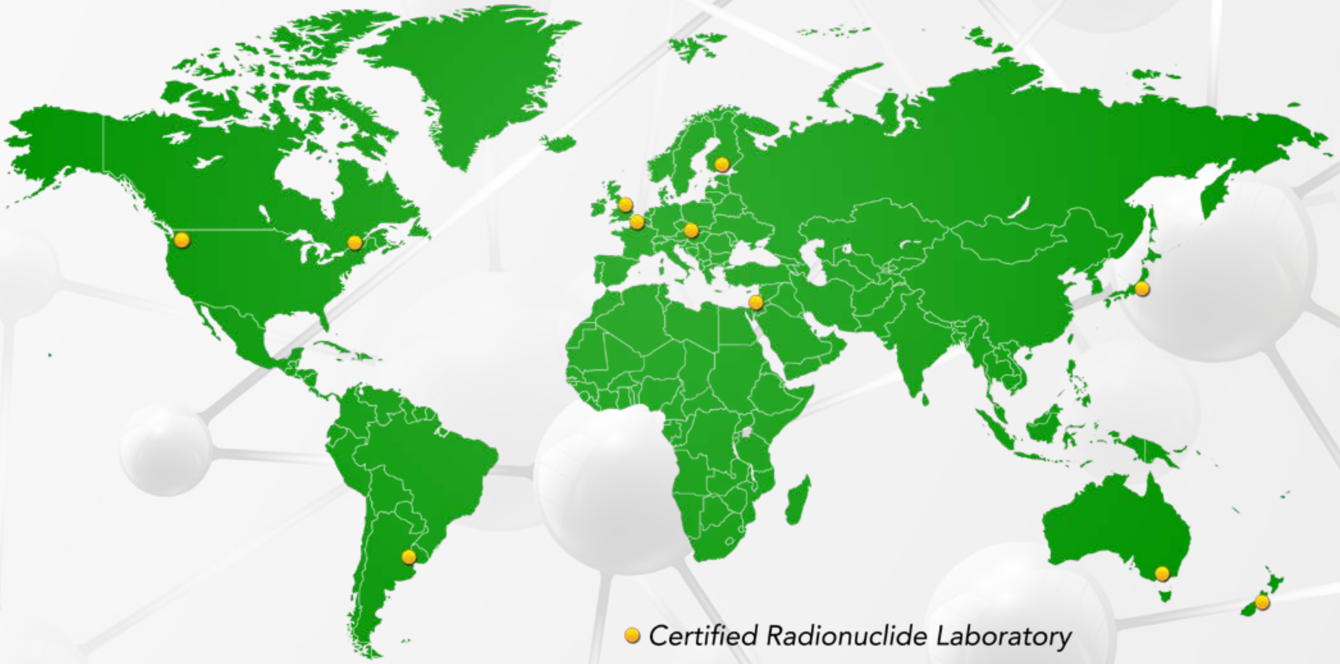
Within RPL, PNNL operates the only radionuclide laboratory in the United States certified by the International Monitoring System of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO).

The treaty, signed by 183 countries, bans all nuclear explosions with the mission of deterring further development of nuclear bombs. CTBTO monitors detect radioactivity from nuclear explosions—whether they occur underground, underwater, on the surface, or in the air—as well as track the spread of radioactivity from emergencies such as the tsunami that struck the Fukushima power plant in March 2011.

Radionuclide Laboratory 16 in RPL was certified in 2007 by the CTBTO. It is one of only 12 laboratories worldwide certified to process air particulate samples collected from a network of 80 stations.

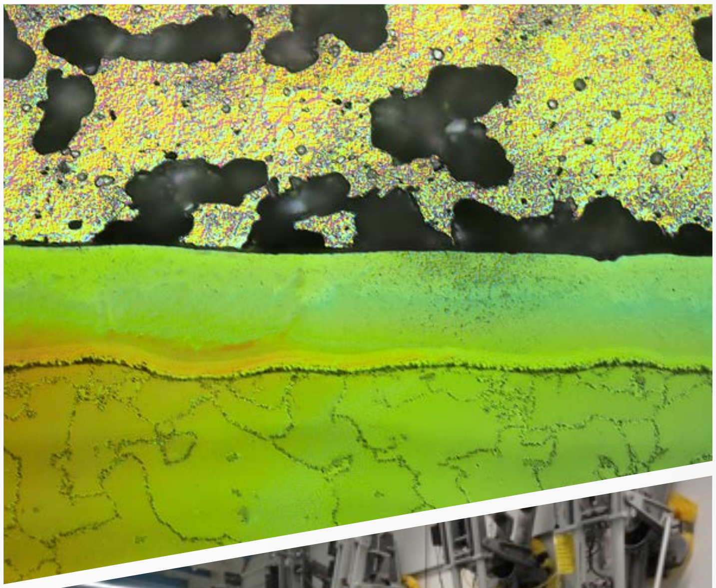
RL-16 is where RPL conducts detailed examinations on about 60 samples annually, using high-efficiency, low-background gamma detectors to look for the presence of nuclides that would be expected to be produced in nuclear explosions.

A nuclear signature does not necessarily mean a weapon was tested illicitly. It could be from a power reactor, medical isotope production, or a release from a particle accelerator. RPL sends its data to CTBTO headquarters in Vienna, where the scientific results inform international policy and response.



Reducing Proliferation Risk by Testing Alternative Fuel for Civilian and Test Reactors

Since 2012, RPL's staff and facilities have played a major role in the nuclear nonproliferation mission through its work on testing uranium-molybdenum (U-Mo) alloy fuel for use in civilian research and test reactors. Non-weapons usable material comprises the U-Mo alloy fuel and its future use will reduce the need for highly enriched uranium fuel, thereby reducing the proliferation risk. Each kilogram of this dangerous material that is no longer needed reduces the risk of a terrorist acquiring it for use in a nuclear weapon, thereby achieving permanent threat reduction. This work is sponsored by the DOE/NNSA, Office of Material Management and Minimization. As of the publication of this document, no reactor runs on this fuel.



Staff at RPL are testing the fuel's thermal physical properties. Researchers section a U-Mo alloy fuel plate into smaller coupons (from 0.5 in^2 to 0.01 in^2) and test them in hot cells with remotely operated video cameras to document the experiments. This test method is cost-effective, reproducible, and obtains many data points efficiently. The RPL is the only facility in the United States that has a complete suite of instruments and facilities to perform this work in an irradiated environment on samples of this size.

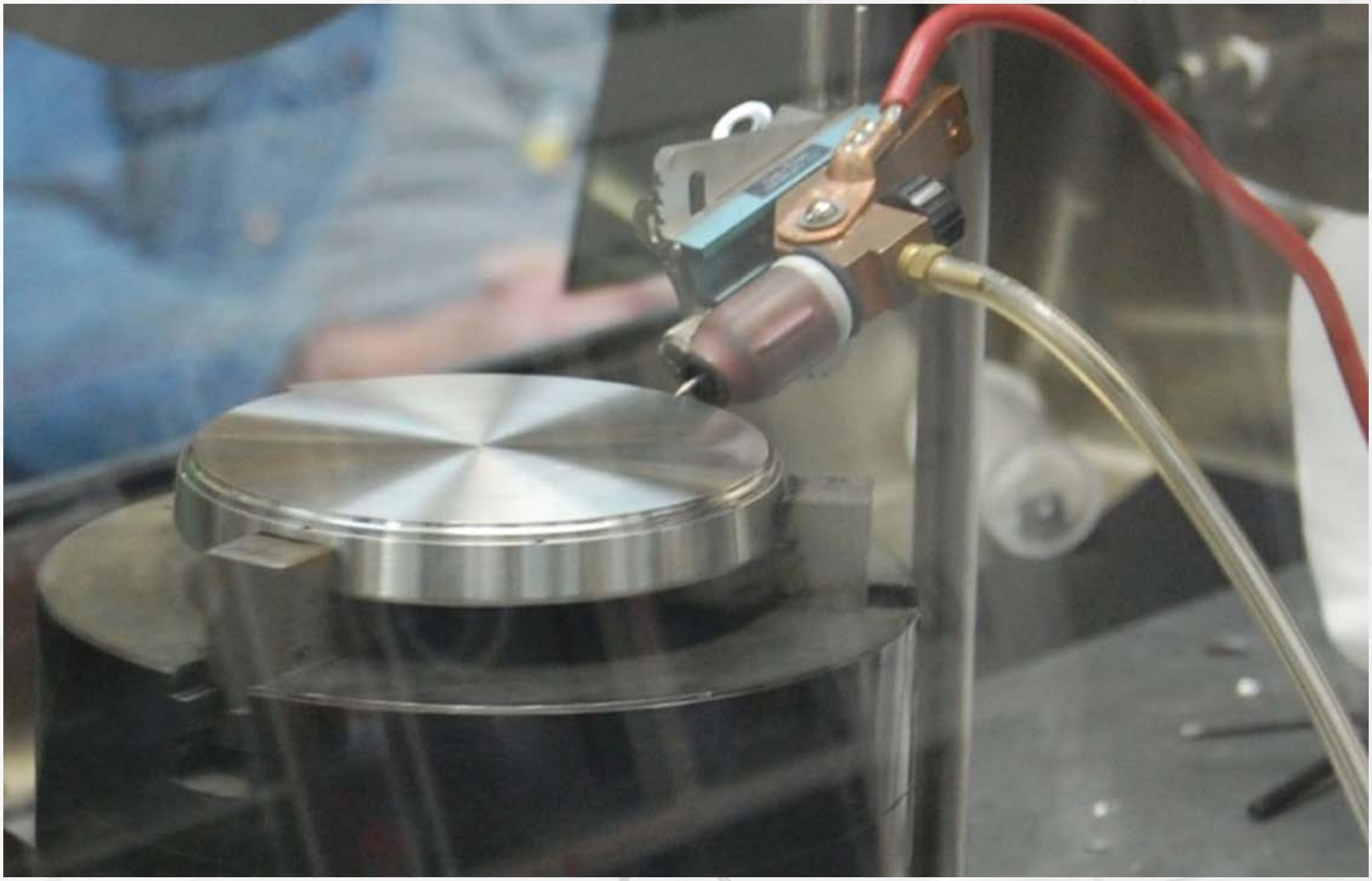
Through the Office of Material Management and Minimization, RPL is able to share the technology and results globally. These experiments have opened the community's eyes on how the alloy fuel works, its performance compared to dispersion fuel, and which reactors can use the fuel.

Producing Sealed Sources to Test Nonproliferation Instruments and Processes

Radioactive sources are important in testing the instruments and processes that are the mainstays of nuclear nonproliferation efforts. Nonproliferation efforts at the borders and ports of entry often include radiation detection instruments, including portal monitors, to scan people, luggage, cargo, and vehicles to prevent the illicit transport of radiological or nuclear material. These instruments need to be tested, and the unique sealed nuclear sources produced in the RPL are a key component in that testing.

The sealed sources produced at RPL contain plutonium and actinides bearing 50 to 200 grams of plutonium. High-quality welding on containers that hold the radioactive material in an inert atmosphere helps make these test objects robust and easy to use. The U.S. Department of Transportation International Atomic Energy Agency Certification of Competent Authority ensures that all quality assurance and safety requirements are met, which allows materials to be shipped internationally and used publicly by research and testing organizations.

The test objects serve a national security mission but also help advance basic science research. For example, North Carolina State University uses the sealed sources to study photoresonance in plutonium.



Aiding Nuclear Forensics Work at a New Test Bed

Since 2013, in a project supporting nuclear security, RPL invested in equipment for a test bed and plutonium processing capability to identify and validate signatures associated with plutonium production. In this test bed, RPL can convert purified plutonium solutions to plutonium oxide for use as exercise and reference material. Plutonium was made for weapons, but the batches were distinct, from different recipes, depending on the production location. Hence, plutonium has specific signatures arising from its originating recipe. In the analysis of an interdicted sample, it is likely that these signatures could play a role in identifying the material's origin, date of separation, and processing location.

RPL's test bed processing capability is unique in the DOE complex and is being used for nuclear forensics work sponsored by the U.S. Department of Homeland Security. The test bed is envisioned to be an enduring capability where scientists and engineers from organizations outside PNNL can conduct nuclear forensics research.

18

RPL: an Enduring Asset for the Nation

The work done in the Radiochemical Processing Laboratory at PNNL has enabled the safe and efficient production of nuclear power, developed improved treatments for cancer patients, driven scientific and legally defensible decisions to clean up the Nation's most complex nuclear waste, and helped prevent the proliferation of nuclear weapons.

Truly a unique resource for the Nation and the world, RPL welcomes international scientists for nuclear science collaboration while simultaneously accommodating the secure conduct of radiological research and analyses sensitive to U.S. interests.

As the missions in RPL have changed over the years, the facility, its capabilities, and research staff have adapted and continued to deliver impactful science. RPL is a cornerstone of nuclear science research in the Nation—a nuclear historic landmark in America.

ABOUT RPL AND PNNL

Housed within the U.S. Department of Energy's Hanford Site in south-central Washington State, the Radiochemical Processing Laboratory is a critical facility at Pacific Northwest National Laboratory. As a DOE Hazard Category II Non-Reactor Nuclear Facility, RPL has enduring missions in environmental management, nuclear energy, national security, and science.

Interdisciplinary teams in RPL and throughout PNNL address many of America's most pressing issues in energy, the environment, and national security through advances in basic and applied science. Founded in 1965, PNNL employs 4,400 staff and has an annual budget of nearly $1 billion. PNNL is managed by Battelle for the U.S. Department of Energy's Office of Science.

For more information about the Radiochemical Processing Laboratory, contact:

Mark Nutt, Ph.D.
Manager, Nuclear Sector
(509) 375-3880 | mark.nutt@pnnl.gov

Paul Bredt, Ph.D.
Director, Nuclear Sciences Division
(509) 375-3699 | paul.bredt@pnnl.gov

Pacific Northwest National Laboratory
Energy and Environment Directorate
P.O. Box 999, MSIN K9-69
Richland, WA 99352

U.S. DEPARTMENT OF ENERGY

Pacific Northwest National Laboratory is managed and operated by Battelle for the U.S. Department of Energy.

PNNL-SA-128385 | September 2018