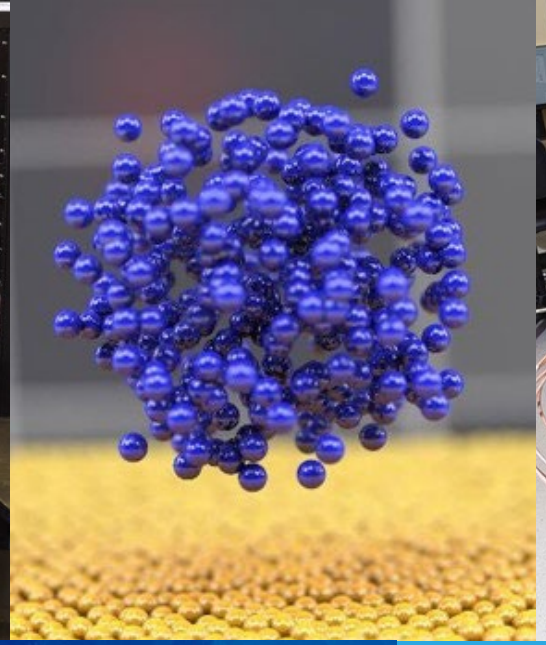



Idaho National Laboratory
Fuel Cycle Science & Technology Overview

INL is managed by Battelle Energy Alliance
for the US Department of Energy

Idaho National Laboratory

Fuel Cycle Science & Technology Division Strategy and Priorities

Mission

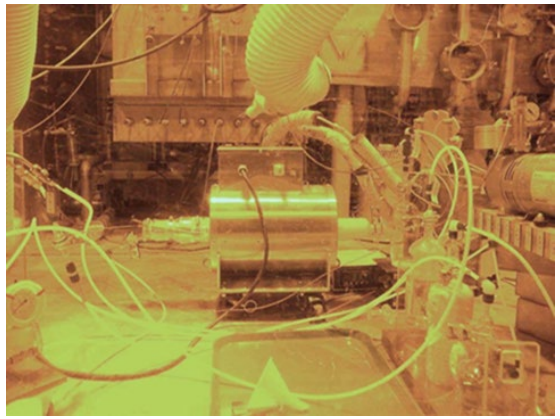
The Fuel Cycle Science & Technology Division delivers innovative leadership in the development and assessment of science and engineering-based solutions for the nuclear fuel cycle, critical materials recovery, and national security related applications through world-class staff and research capabilities.

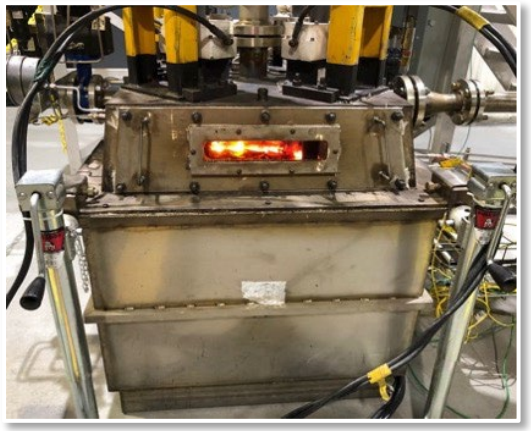
Scope

- Perform world-class aqueous and electrochemical separations research, from fundamentals to applied engineering demonstrations.
- Leverage molten salt expertise to develop deeper understanding of molten salt chemistry and process monitoring in support of advanced reactor concepts.
- Provide comprehensive and innovative solutions to the challenges of storage, transportation, and disposition of used nuclear fuel.
- Advance separation science, especially for lanthanides and actinides, supporting all three mission areas of the laboratory:
  - NS&T – nuclear fuel cycle, waste management, feed for advanced reactors, isotopes and medical applications, and radiation chemistry
  - N&HS – non-proliferation, signatures, training, and classified programs
  - EES&T – critical materials (e.g., rare earth recovery and recycling)

Aqueous Separations

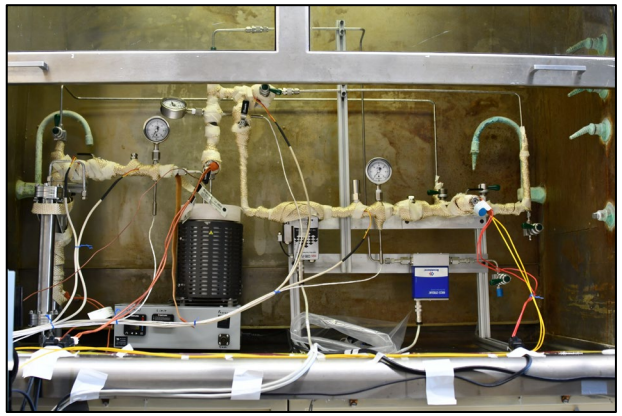
- Flowsheet development and testing for advanced fuel cycles and critical materials recovery/separation
- Off-gas capture (I and Kr)
- Radiation chemistry
- Solvent degradation chemistry
- Aqueous complexation chemistry
- High-assay LEU recovery from zirconium and aluminum fuels
- HEU/HALEU polishing/down-blending/conversion
- National security missions (Athena & Beartooth)
- Critical minerals and materials strategic initiative (Zr, Hf, U, Ln)

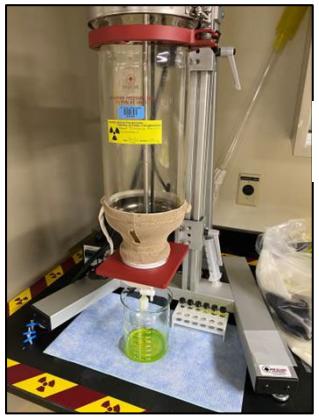




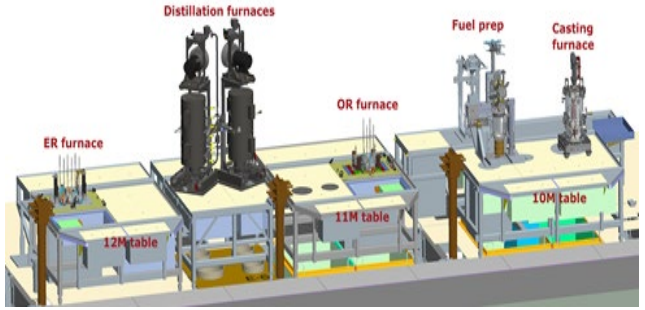
Pyrochemical Science

- Recycling of oxide and metallic used nuclear fuels
- Immobilization processes and waste forms
- Base and strategic metal recovery/recycle/purification
- Safeguards and material accountancy in high temperature systems
- Used fuel recycling process modeling
- EBR-II driver fuel processing technical support



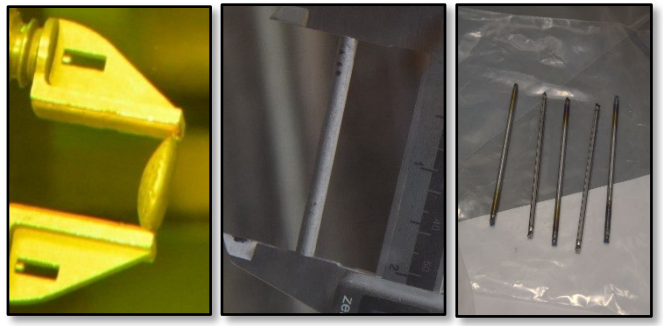


Advanced voloxidation and direct extraction capability under development for hot cell installation



Schematic of Scalable Pyrochemical Recycling (SPyRe) Testbed in HFEF

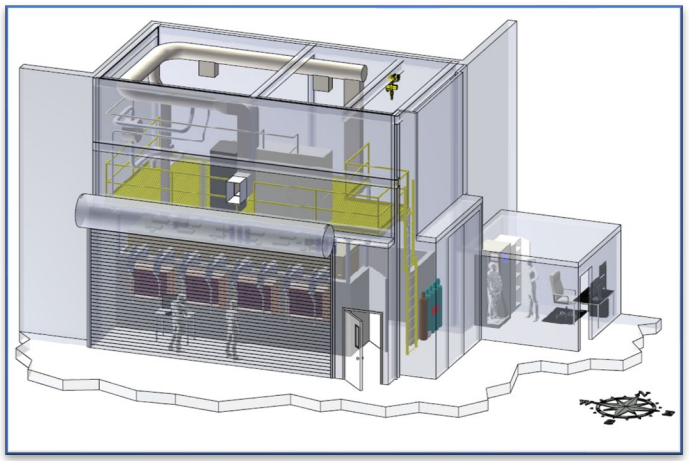
Modular Electrorefiner Test Station



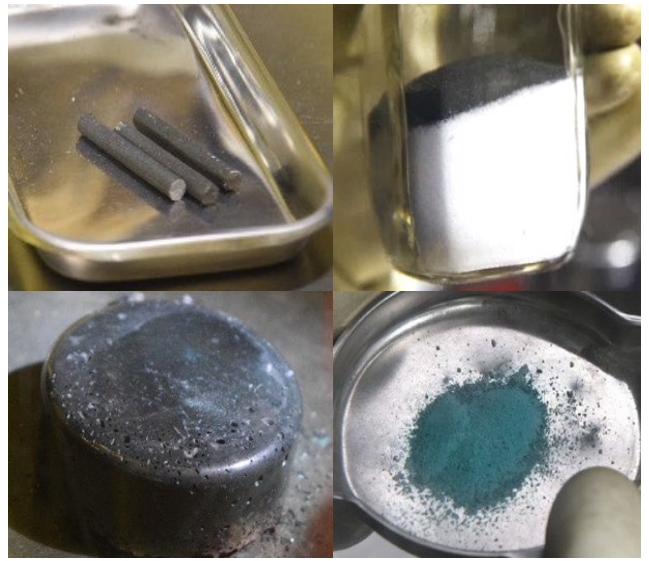
~100 gram U/TRU product, metallic fuel, and test rodlets produced from recycled oxide fuel

Advanced Technology of Molten Salts

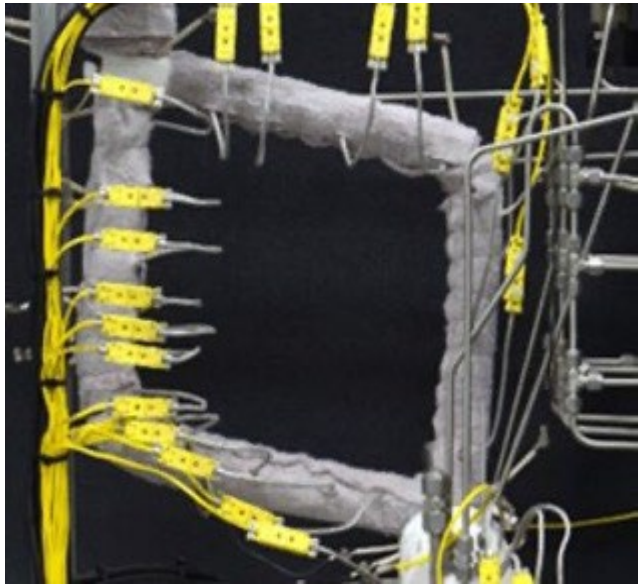
- Synthesis and purification of salts, specifically, proprietary fuel salt compositions needed for testing of novel advanced reactor concepts.
- Development of the world's first center for post-irradiation examination of molten fuel salts with the Molten Salt Thermophysical Examination Capability (MSTEC).
- Research facilities provide the nation with an experimental testbed for fundamental studies on corrosion, thermophysical properties, and speciation for solar, energy storage, uranium, transuranic, and irradiated salts at high temperatures.
- Team is actively supporting mission essential design and development for advanced reactor demonstrations, including the molten chloride reactor experiment (MCRE).
- Team actively engages with the broader molten salt community to support development of Multiphysics modeling and simulations, educate and grow the next generation of scientists, and maintain world leading expertise in molten salt technologies.



MSTEC Transuranic Shielded Glovebox



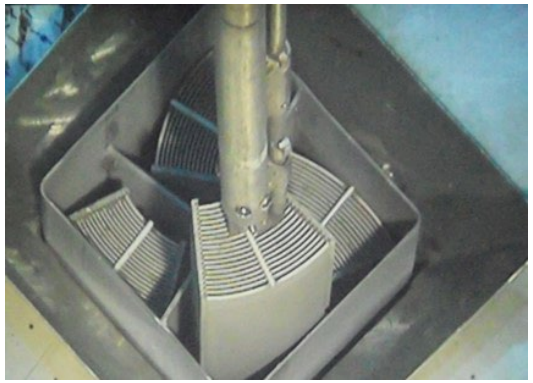
$PuCl_3$-NaCl fuel salt fabrication starting from plutonium metal rods.



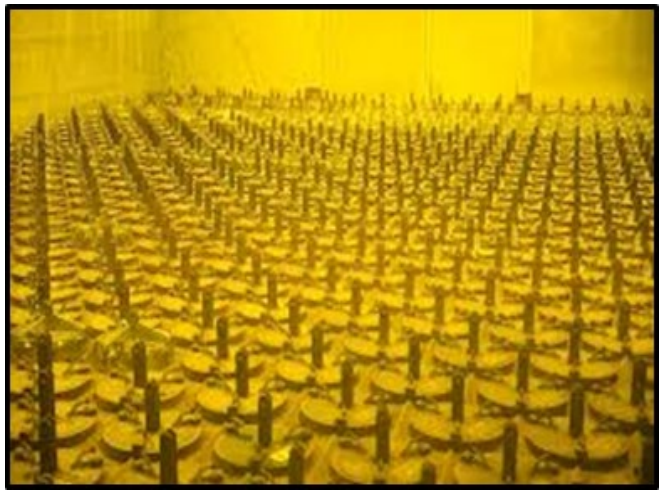
Terra Power $PuCl_3$ Flow Test Loop

Used Nuclear Fuel Management

- Used nuclear fuel transportation, packaging, and interim storage
- Disposition of DOE-EM legacy materials
- Commercial and non-commercial used fuel disposition
- Used nuclear fuel monitoring and instrumentation



Advanced Test Reactor fuel elements

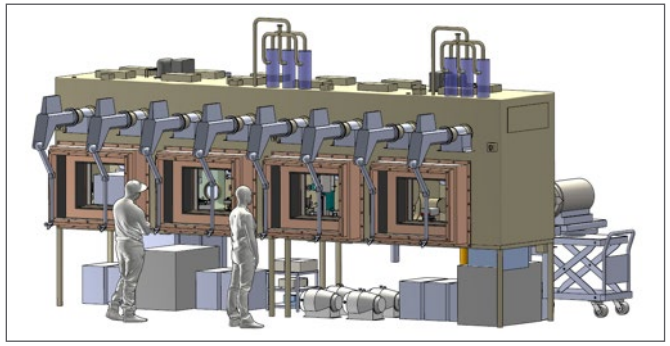


CPP-603: dry storage system at the INL site

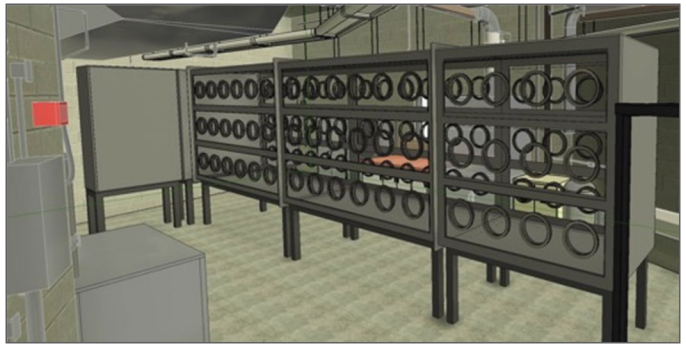
Upcoming test beds available at MFC

Modern facilities to engage and train the next generation of fuel cycle experts

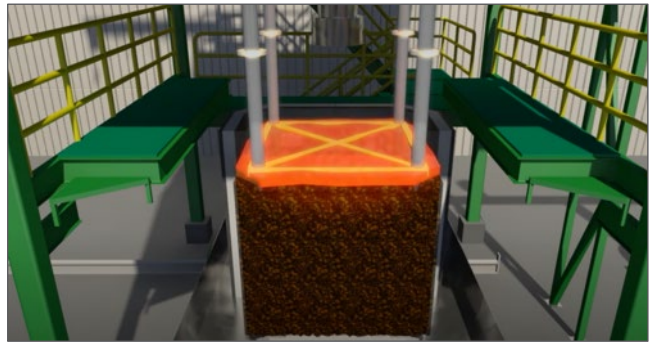
All new fuel cycle test beds are designed with the ability to demonstrate innovative safeguards and security concepts applicable to advanced reactors and their fuel cycles in support of national security objectives.



Molten Salt Thermophysical Examination Capability (MSTEC)
Platform to design, demonstrate, license, and operate MSRs



Beartooth - SNM Test Bed
Aqueous processing platform for demonstrating new safeguards and security concepts applicable to advanced fuel cycle operations



Sustainability – WM Test Bed
Platform to develop better more stable waste forms for final disposition in support of advanced reactor development and to address DOE legacy waste issues.

Idaho National Laboratory

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.