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Lawrence Livermore National Laboratory - Increaseing Plutonium Capabilities

D. C. Riley, M. C. Bronson, J. A. McNeese, S. A. Stout, K. S. Holliday

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Lawrence Livermore National Laboratory Increasing Plutonium Capabilities

David Riley, Mark Bronson, Jim McNeese, Stephen Stout, Kiel Holliday.
Lawrence Livermore National Laboratory, Livermore, CA, USA.

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Abstract

Lawrence Livermore National Laboratory (LLNL) has been deeply involved in development of plutonium processing techniques and plutonium processing for decades. Currently work is being performed in the areas of plutonium processing, part fabrication, material characterization, analytical chemistry, plutonium science, and development of shipping packages. Plutonium processing efforts support all NNSA programmatic missions. A replacement Recovery Laboratory is being installed to ensure programs can recover high value plutonium assets and process low value assets for disposal. Part fabrication activities support the manufacturing of new targets for use in the Joint Actinide Shock Physics Experimental Research (JASPER) gas gun, Corrosion Studies, and Pit Surveillance test parts. Material characterization (MC) and analytical chemistry (AC) capabilities support all programs and additional capabilities are being added to assure LLNL capabilities meet NNSA needs. New MC and AC capabilities include: AUGER Spectrometer, X-Ray Photoelectron Spectrometer (XPS), Atomic Emission Spectrophotometer (AES) and a nano-dilatometer. LLNL is currently developing the DPP-1 package for use by the US DOE Defense Programs. These is also ongoing work to remove unused gloveboxes and equipment to make room for end of life replacements and new capabilities, thus, assuring that LLNL has the capabilities necessary to meet ongoing NNSA nuclear material needs.

Background

LLNL has been working with nuclear materials for over 50 years. In 2012, the plutonium facility went through a de-inventory effort to reduce the plutonium facility nuclear holding to below a Security Category II. This effort was done at the request of the Department of Energy/National Nuclear Security Administration (DOE/NNSA) to reduce the security costs for operating the facility. This reduction of allowable nuclear material resulted in changes of how programs are operated at LLNL. The reduction of material has resulted in a shift of the LLNL activities to performing more scientific based efforts. Therefore, we are currently installing addition capabilities to perform additional needs for plutonium science.

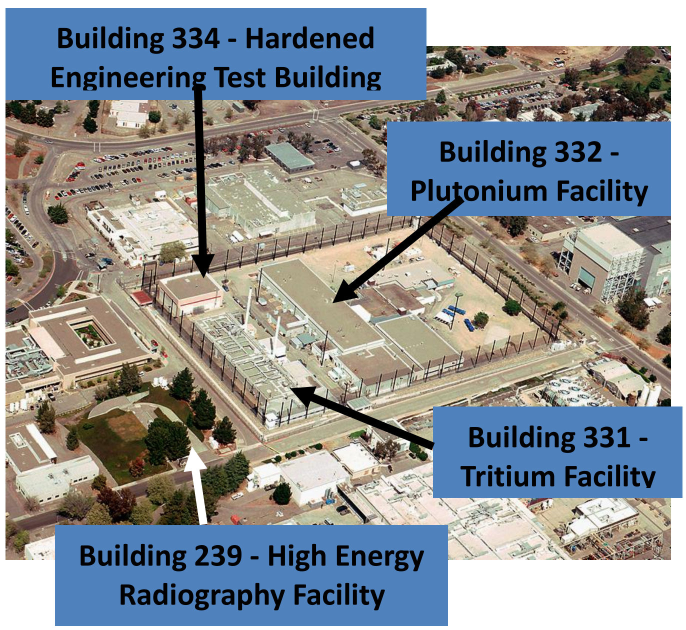
Programs

Working with these materials requires the integration of program needs with facilities and capabilities. LLNL currently supports a broad range of different programs. Some of these include:

Nuclear Weapons Assessment and Certification	Pit Surveillance
Plutonium Aging and Surface Science	Surety Technology Development
W87 Pit Manufacturing Design Agency Activities	LEP Pit Certification and Surety Efficacy Testing
Pit Reuse Development	Tritium Recovery and NIF Support
Nuclear Counter Terrorism (NCT)	Arms Control and Safeguards Radiation Detection
Nuclear Forensics (P4 Mission)	Nuclear Emergency Response Training (JTOT)
Criticality Safety Training	

Facilities

These programs are performed in a number of facilities at LLNL. The facilities range from Hazard Category 2 down to radiological. Most of the material is handled in the 3 Hazard Category 2 Facilities: Plutonium Facility (B332), the Hardened Engineering Test Building (B334), and the Radiological Facility (B239).



There are 2 Hazard Category 3 facilities (Material Science (B241) and Tritium Facility (B331). These facilities handled smaller items and tritium. There are an additional 13 other facilities that handle nuclear material that are less than Hazard Category 3.

We also work in cooperation with other sites and have teams that are conducting activities at Los Alamos National Laboratory (LANL), Nevada Nuclear Security Site (NNSS) and at Idaho National Laboratory (INL). Some of the programs at these sites including: Pit operations at LANL to support the Nuclear Weapons Assessment and Certification. This program is also supported at NNSS through the use of the Joint Actinide Shock Physics Experimental Research (JASPER) for studying the physics of plutonium under high pressures. The NCT and Arms Control and Safeguards Radiation Detection Programs are supported at the NNSS and INL. LLNL also runs some of the Criticality Safety Training at NNSS.

Activities

LLNL performs a broad spectrum of activities with nuclear materials including plutonium processing, part fabrication, material characterization and analytical chemistry, and development of shipping packages. To support these activities we have the full breath of installed nuclear material capable equipment. Due to changes needs, LLNL is currently installing equipment to upgrade our capabilities.

Plutonium Processing

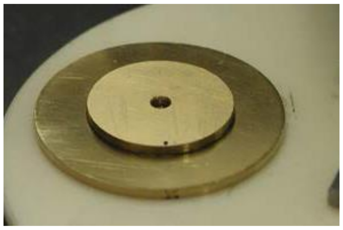
LLNL has installed and is operating a plutonium processing line to recover ^{238}Pu from NNSA components. In addition to the recover process the material will be processed to separate ^{234}U from the ^{238}Pu.

A replacement Recovery Laboratory is being installed to improve recovery of high value material from scraps and residues as well as replace aging equipment. Various processes at LLNL generate scrap and residue materials such as: pyrochemical operations, hydride dehydride casting (HYDEC), foundry, Materials Characterizations and Analytical Chemistry, machining and small scale studies. With the new recovery laboratory we will be able to recover more material and to a higher purity. The recovery laboratory consists of three glove box lines (Figure 2). The process flow sheet of the new recovery line is shown in Figure 3. The recover laboratory has three types of feeds. These include non-salt small metals and oxide residues, salt residues, and larger metal scrap. The processing of the small metal and oxide residues involves dissolution of the material, performing ion exchange on it. The ion exchange process produces very pure plutonium solutions. Then precipitating the plutonium and calcining the material to oxide. This clean oxide is available for reuse. For the salt residues, the material is washed to remove the solids then it is processed as the non-salt residues. For larger pieces of metal they are calcined and recovered with the non salt oxides.

To accommodate the new recovery laboratory, LLNL removed glove boxes and equipment from an underutilized laboratory. The room was cleared out of 6 gloveboxes in 2 years (Figure 4). All of these gloveboxes were decontaminated and reduced to fit within standard waste boxes. We are in the process of installing the new glovebox lines.

We are also involved with the formation and separation of various actinide metals and compounds. Recently ^{242}Pu metal was generated to support a research effort.

Part Fabrication



Small scale parts fabrication is an important effort to support programs at LLNL. This has included producing targets for the JASPER program and targets for the Z machine at Sandia. LLNL also generated parts to support the material characterization effort (tensile, weld, density, corrosion and pit surveillance test specimens).

We currently have diamond saws, lapping stations, sputter coater, manual and CNC lathes, manual and CNC mills, and rolling mill. For parts inspection we have height gages, surface analyzers, and Moore measuring machines.

We are in the processes of adding additional capabilities to our part fabrication capabilities. These include: a sintering furnace for non-metal part fabrications, an arc-melting furnace, and sampling capability at NNSS.

Material Characterization and Analytical Chemistry (MC/AC)

LLNL has had a strong need for MC/AC to support the plutonium programs. Material characterization examines a full suite of material properties including: impurity content, strength, grain structure, voids and inclusions, density, phase distribution, impurity distribution, lattice parameters, corrosion properties, surface analysis and other properties. Over the years we have developed separations chemistry to achieve accurate measurements of low yield fission products. LLNL has used the analytical chemistry and material characteristic data and other data to capture knowledge about world-wide plutonium processing. This has been captured in a Wiki framework to make it more usable for nuclear forensics.

LLNL operational material characterization equipment includes: microprobe, optical metallography, x-ray photoemission spectrometer, tensile tester, transmission electron microscope, inductively coupled plasma mass spectrometer, immersion density, dilatometer, Auger nanoprobe (SAN), hardness tester, focused beam/environmental scanning electron microscopy, and x-ray diffraction (Figure 5).

We are currently upgrading our capability with the recent installation of interstitial gas analyzers which began operation in 2015. These analyzers are designed to analyze for carbon, sulfur, oxygen, nitrogen and hydrogen. A new sample dissolution glovebox was installed in 2016 to prepare samples. An Atomic Emission Spectrometer (AES) and a JOEL JXA-8230 SuperProbe Electronic Probe Microanalyzer (EPMA) is in the process of being installed for use in 2017.

Shipping Containers

LLNL is also the design authority for a new shipping package which is a replacement for an old shipping package, the FL. This new design is expected to be able to increase the ability to ship materials between sites.

Anticipated Future Capabilities

LLNL is working with NNSA to and LANL to increase the production of samples for Plutonium Science. To support all programs our equipment and facilities will continue to be upgraded. This will involve removing outdated equipment to make room for the new. This will ensure that LLNL has the capabilities to need DOE/NNSA nuclear material program needs.

Figure 2: The Recovery Laboratory

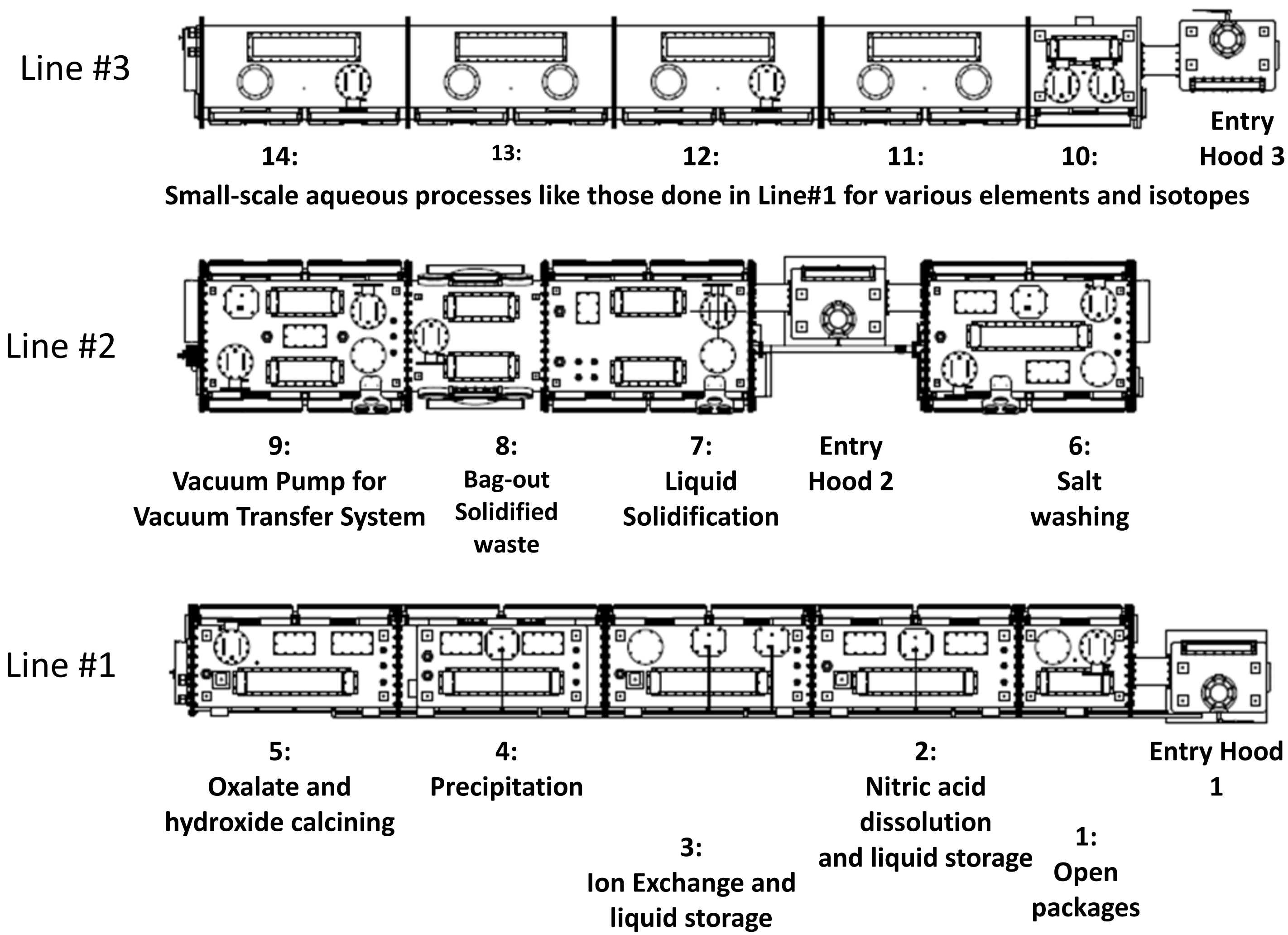


Figure 3: Recover Laboratory Flowsheet

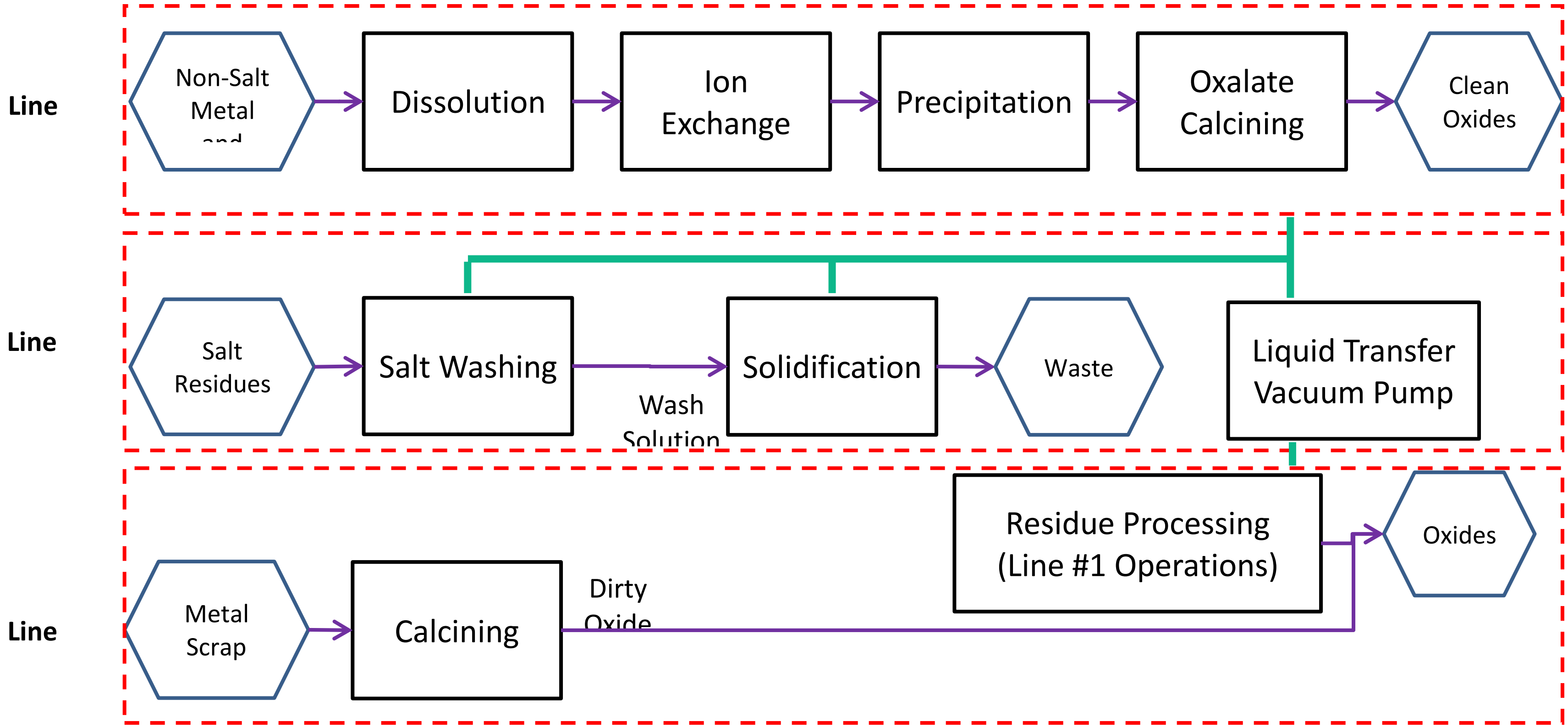


Figure 4: Transformation of space to accommodate the New Recovery Laboratory.

Figure 5: Materials Characterization and Analytical Chemistry equipment