Refurbishment of LANL’s Heat Source Manufacturing Infrastructure to Meet Future Mission Needs

Anastasia D. McLaughlin\textsuperscript{1a}, Drew E. Kornreich\textsuperscript{1b}, and R. Marc Burnside \textsuperscript{1b}

\textsuperscript{1a}Integrated Program Management Division and \textsuperscript{1b}Applied Engineering Technology Division, Los Alamos National Laboratory

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Overview

- Brief history of LANL’s experience in developing, characterizing, testing, and manufacturing $^{238}\text{Pu}$ heat sources.
- Plans for future infrastructure improvements utilizing a graded approach.
- Operational considerations and challenges involving $^{238}\text{Pu}$ glovebox maintenance and operation.
- Example of how we have successfully employed the graded approach toward revitalization.
Program Objectives

- Produce GPHS fueled clads to be used for future space missions
  - Invest in a robust equipment maintenance program and capital assets to ensure a viable long-term heat source capability
  - Maintain personnel capabilities across the production flowsheet to facilitate manufacturing
  - Reduce processing time and expense through initiatives like utilizing the new TA-55 analytical chemistry suite and reducing the Material at Risk (MAR) via material stewardship initiatives
- Complete impact testing to support launch safety analysis studies
NASA Heat Source Designs

- **General Purpose Heat Source (GPHS)**
  - PuO$_2$ sintered pellet
  - Iridium cladding with vent
  - Produces $\sim 60W_{th}$

- **Light Weight Radioisotope Heating Unit (LWRHU)**
  - PuO2 sintered pellet
  - Pt-30Rh cladding
  - Produces $\sim 1W_{th}$
  - Assembled into a graphite aeroshell
LANL Process for Producing Pu$^{238}$O$_2$

1. Pu 238 Fuel Supply
2. Aqueous Processing
3. Fabrication of PuO$_2$
4. Pellet Encapsulation
5. Quality Approval
6. Ship

Note: QA checks are utilized throughout production flowsheet.
Significant Contribution to Heat Source Program

- Provided development and fabrication information to Mound facilities for the plutonia-molybdenum-cermet fuel used in the Pioneer, Transit, and Viking missions (early 1970s)
- Provided development and fabrication information to the Savannah River Site (SRS) for the improved Multi-Hundred Watt fuel form that was used on the Galileo mission (mid 1970s)
- Supported the long range developmental program to determine the effects of fabrication parameters on fuel microstructures (LA-5622-MS) 1974
- Supported the heat source program to develop a nuclear powered artificial heart (LA-6669-PR) September 1976
- Provided the fabrication flowsheet to SRS for the General Purpose Heat Source (GPHS) fuel pellets (LA-7972-MS) August 1979
- Provided impact testing to support launch safety with the analysis of more than 50 impacts analyzed between 1974 and 2010
- Manufactured more than 2600 milliwatt heat sources (1980–1990)
Decades of Manufacturing Experience

- Produced 134 Light Weight Radioisotope Thermal Heating Units (LWRHU) for the Galileo mission (1987)
- Supported the milliwatt RTG surveillance mission transferred to LANL (1990 to present)
- Transferred GPHS production from SRS to LANL and produced 235 GPHS FCs for the Cassini Mission (1994 – 1996)
- Produced 180 LWRHUs for the Cassini Mission (1997)
- Transferred aqueous processing from SRS to LANL (2000)
- Produced 21 GPHS fuel clads (FCs) for the Pluto/New Horizons mission (2004)
- Produced 26 GPHS FCs for the Mars Science Laboratory mission (2010)
- Produced 25 GPHS FCs for the Advanced Sterling Radioisotope Generator (ASRG) project
- Currently performing development and qualification activities to resume milliwatt heat source and RTG production including RTG assembly
Plutonium Facilities

Plutonium Facility, PF-4

Chemistry and Metallurgy Research (CMR)

Radiological Laboratory Utility Office Building (RLUOB)

Radioactive Liquid Waste Treatment Facility (RLWTF)
Los Alamos operates a system of nuclear facilities that provides goods and services to multiple customers in accordance with the requirements from multiple regulators.

The operating environment inside of PF-4 is challenging with multiple requirements sets from both customers and regulators.
- It defaults to LANL to integrate all of these requirements and safely deliver products to customers.

The vast majority of physical resources in PF-4 are shared resources that are not unique to any one program. It is also the contractors responsibility to ensure the combined program requirements can be met with the available resources.
- We do this through the integrated nuclear planning process.

**Policy Level**
- Program Drivers

**Program Requirements**
- (can change in months)

**Technical Capabilities and Capacity**
- (can change in years)
Facility Infrastructure Investment

- The Complex Transformation Environmental Impact Statement designated LANL as the nation’s Plutonium Center of Excellence. Continued investment at LANL supports this designation and provides an overall cost savings to DOE and Work for Other customers such as NASA.
  - Cost sharing
  - Focused expertise
  - Reduces hazardous shipments

DOE funds extensive facility upgrades that all programs can leverage
LANL’s Infrastructure improvements will focus on providing the facilities, equipment, and capabilities to meet NASA mission needs for the next 20 years, aiming to minimize material movement thereby decreasing processing time.
Investment Focus Areas

- Reduce Risk Single Point Equipment Sets
  - Install Redundancy
  - Increase Reliability
- Increase focus on Maintenance
- Co-locate flowsheet operations through:
  - New glovebox installations
  - Process equipment installations in existing gloveboxes
## Mitigating Single-Point Equipment Risks

<table>
<thead>
<tr>
<th>Priority</th>
<th>Single Point Failure</th>
<th>Revitalization Method</th>
<th>Timeframe</th>
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<tbody>
<tr>
<td>1</td>
<td>Hot Press</td>
<td>Increase Redundancy: Installation of new glovebox &amp; Hot Press 4</td>
<td>FY15 - FY18</td>
</tr>
<tr>
<td>2</td>
<td>GPHS welder</td>
<td>Increase Reliability: System controller and power supply upgrade</td>
<td>FY15- FY16</td>
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<tr>
<td>3</td>
<td>Isotope Fuel Impact Tester</td>
<td>Increase Reliability: System controller upgrade</td>
<td>FY17- FY19</td>
</tr>
<tr>
<td>4</td>
<td>9516 welder</td>
<td>Increase Reliability: System controller and power supply upgrade</td>
<td>FY17- FY19</td>
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<tr>
<td>5</td>
<td>9516 radiography</td>
<td>Increase Reliability: System controller upgrade</td>
<td>FY19 - FY20</td>
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<td>6</td>
<td>Particle size analyzer</td>
<td>Increase Reliability: Installation of New Process Equipment in existing glovebox</td>
<td>FY18</td>
</tr>
<tr>
<td>7</td>
<td>Metallography</td>
<td>Increase Reliability: Installation of New Process Equipment in existing glovebox</td>
<td>FY16</td>
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Maintenance

- Maintenance of equipment utilized for direct product production is robust.

- Additional focus is being placed on extending glovebox life through:
  - Glovebox Window Replacement
  - Glovebox Spool Replacement/Refurbishment

- Proactively initiating corrective maintenance on historic equipment sets to increase production redundancy and decrease downtime.
Co-Locating Flowsheet Elements

- Utilizing the Plutonium Science and Manufacturing Equipment Lifecycle Guide:
  - Successfully identifying under-utilized gloveboxes for new process equipment installation:
    - Gas-Sampling Operations
    - Second GPHS Welder
    - Additional Oxide Conversion Furnaces
  - Designing new glovebox and equipment installations to maximize product throughput and minimize material movements
Example: Hot Press #4 and Oxide Conversion Furnaces

- Current material flow requires operators to move material through 12 gloveboxes and a trolley truck line to progress from PuO$_2$ furnace operations (granular seasoning) through pellet pressing (Hot Press)
- The Hot Press #4 and Oxide Conversion Furnace Project reduce number of glovebox transfers to 4
Challenges with Revitalization & Continuing Operations

• During glovebox revitalization efforts additional contamination control is required.
• This reduces availability of that glovebox and adjacent gloveboxes.
• Glovebox availability is impacted depending on complexity of the job.

Job coordination and utilization of a baselined resource loaded schedule are paramount for effective room management.
Revitalization Success: Analytical Chemistry Transition

- Plutonium-238 analytical chemistry capability has transitioned from CMR to TA-55 (200 Area and RLUOB)
  - DC-Arc instrument on-line in FY 2014
    - Installation & Readiness complete
    - Qualification activities complete
  - Radiochemistry process
    - Installation & Readiness complete
    - Qualification activities complete
  - Plutonium assay
    - Installation & Readiness complete
    - Qualification activities complete

- Plutonium Isotopics
  - Baseline uses TIMS Instrument in the new RLUOB building with sample preparation in the 200 Area.
  - Gamma spectroscopy has shown promise as a replacement technique providing a cost savings

Transition resulted in a 3-4 week reduction in obtaining sample results thereby reducing customer cost
Revitalization Success: Product & Sample Container Welding

- Completed installation of two modern AMET welding control systems in existing gloveboxes.
- Upgrade included modern controllers and automated axis control.

Upgrade increased system reliability and allows for dual utilization thereby decreasing processing time.
Los Alamos operates a system of nuclear facilities that provides goods and services to multiple customers in accordance with the requirements from multiple regulators.

The vast majority of physical resources in PF-4 are shared resources that are not unique to any one program. This allows for extensive facility based cost sharing to reduce single program capability costs.

Our objective is to ensure a “balance” between resources and requirements that continuously ensures safe and secure execution of plutonium missions.

78 Gloveboxes and 71 major pieces of equipment are utilized to store, recover, manufacture, and test $^{238}\text{PuO}_2$ heat sources.

LANL is employing a graded revitalization approach to extending useable equipment and glovebox life for missions. This allows for reduced customer cost as well as continued production occurring simultaneously with revitalization.

Program is dedicated to maintaining safe and secure operations and improving process quality and efficiency as we continue to move through the next 5 years worth of revitalization efforts.