Isotope Management for Space and Defense Power Systems

2nd Workshop on Isotope Federal Supply and Demand

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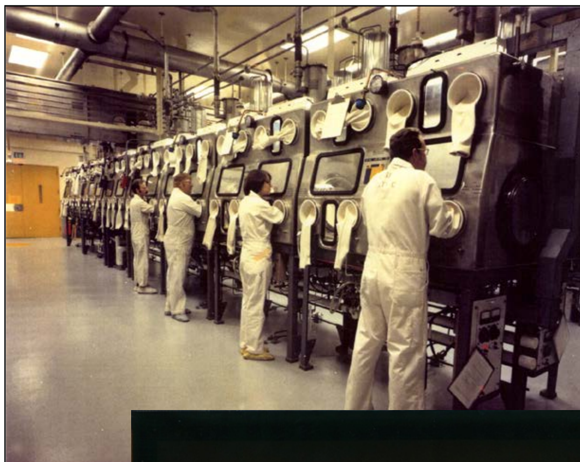
Space and Defense Power Systems Program

Purpose: Provide nuclear power sources for space science and exploration missions and national security applications for which solar energy or other power sources are inadequate.



Radioisotope Power Systems (RPS)

- **Two families of Radioisotope Systems**
  - **Power generators (Watts to 100's of Watts of electricity)**
  - **Heater units (1 Watt of heat)**
- **Long history of RPS use in space**
  - First launch in 1961
  - Used safely and reliably in missions for over 50 years
    - » 6 on the Moon (1960s - 1970s)
    - » 8 in Earth orbit (1960s - 1970s)
    - » 5 to Mars (1975, 1996, 2003, 2011)
    - » 8 to outer planets and the Sun (1970s - 2006)

- **Long history (decades) of RPS use in national security applications**
- **Also current and past development of fission power systems for NASA and national defense needs**

DOE RPS Responsibilities

- Maintain RPS production infrastructure capability
  - Includes management of SNM inventories (Pu-238, Np-237)
- Develop, produce and deliver RPS for mission applications
  - Design, development, fabrication, evaluation, testing, delivery to meet overall system requirements, specifications, schedules and interfaces as agreed with user agencies
- Conduct nuclear safety analyses in support of NEPA and nuclear launch approval
- Provide liability indemnification for damages resulting from a nuclear incident

Why Pu-238 as a Heat Source?

- Long half-life- 87.7 years
- High power density/specific power ~ 0.57 watts/gram
- Low radiation levels – primarily an alpha emitter
  - limit radiation exposures of operating personnel during production, fabrication, testing and delivery
  - low-mass configurations for space applications offer very little self shielding
  - compatibility with sensitive instrumentation for space exploration
- High thermal stability – oxide form with high melting point
- Low solubility rate in the human body and environment
- Producible in sufficient quantities and schedule to meet mission needs
- Other isotopes considered and dismissed over the years
  - investigated several times in response to concerns over supply

Pu-238 Supply History

- Historically, Pu-238 was produced at Savannah River Site using Pu-239 production reactors and chemical processing facilities
- Production ceased in 1988 due to downsizing of the DOE nuclear weapons complex
  - Last remaining SRS operating reactor, K-Reactor, shut down in 1996
  - 1992 decision to phase out operations at the two chemical processing facilities (F-Canyon and H-Canyon)
  - Np-237 solution was converted to solid oxide form and shipped to Idaho National Laboratory for storage
- Requirements for Pu-238 currently being met from existing domestic inventory and purchases from Russia
- DOE has allocated 35 kg of Pu-238 to civil space applications
  - Of the allocation, 17 kg is currently within specifications for use in current RPS designs
  - The balance can be used as blend stock to extend the usefulness of newer material

Current Plans for Pu-238 Production

- Pu-238 Supply Project was initiated using NASA funds in FY 2012
- Planned production capacity is an average 1.5 kg oxide/year
- Required production level can be met with existing, operating isotope separations facilities at ORNL
- Target irradiation will be conducted in existing reactors (ATR and HFIR)
- The project has completed NEPA activities and alternatives analysis to select approach
- Tests are underway to finalize the HFIR target design and optimize needed processes
- If fully funded, the production capability will be fully operational by Spring 2021

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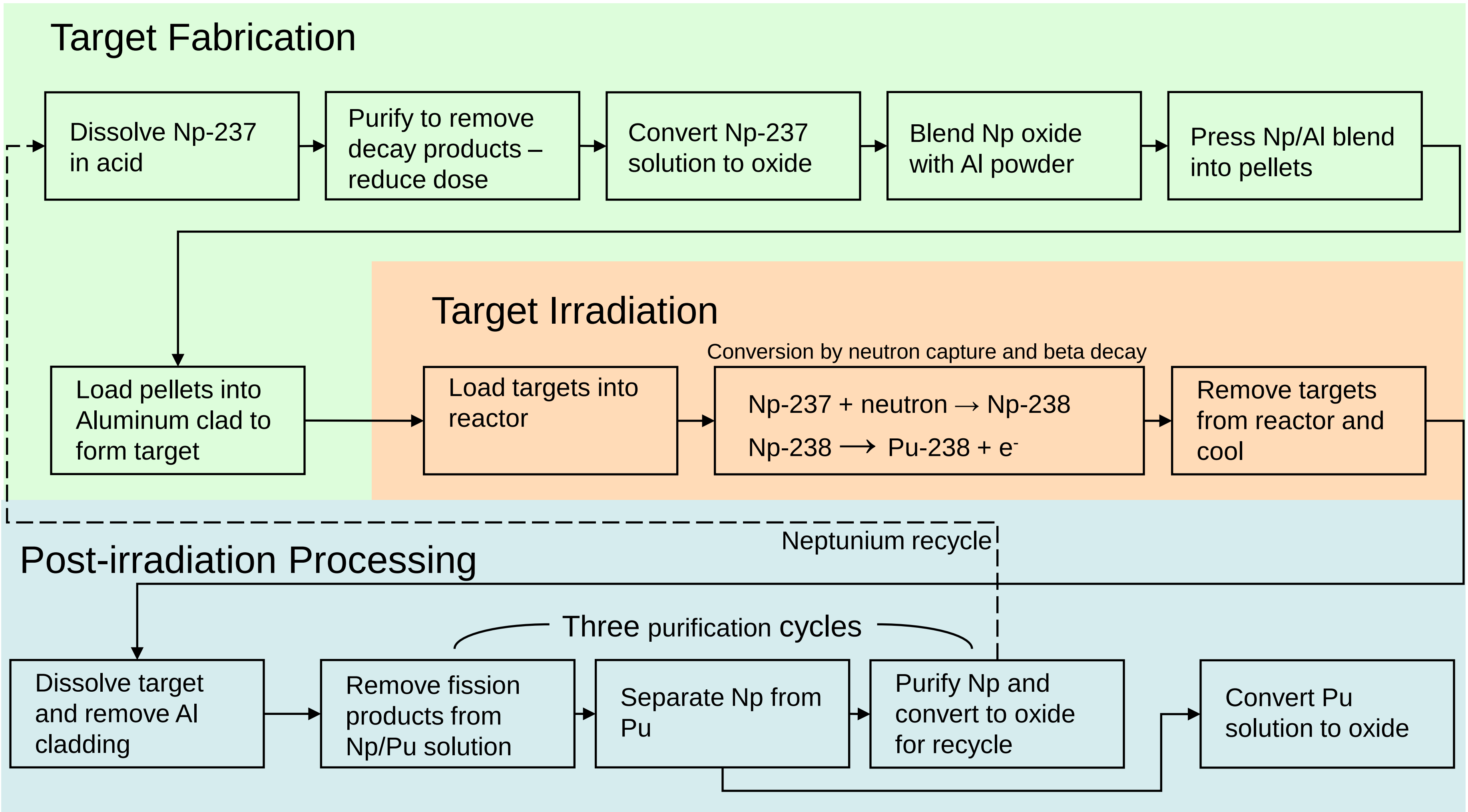
Nuclear Energy

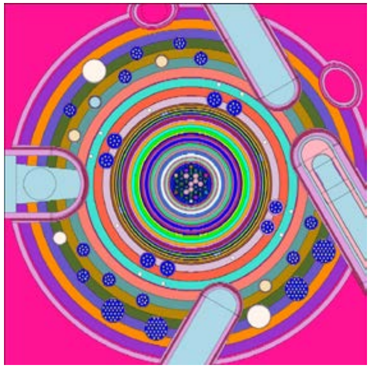
Pu-238 Production Process Flow

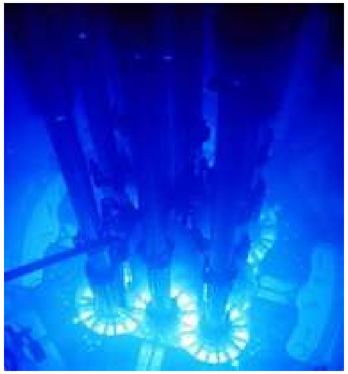


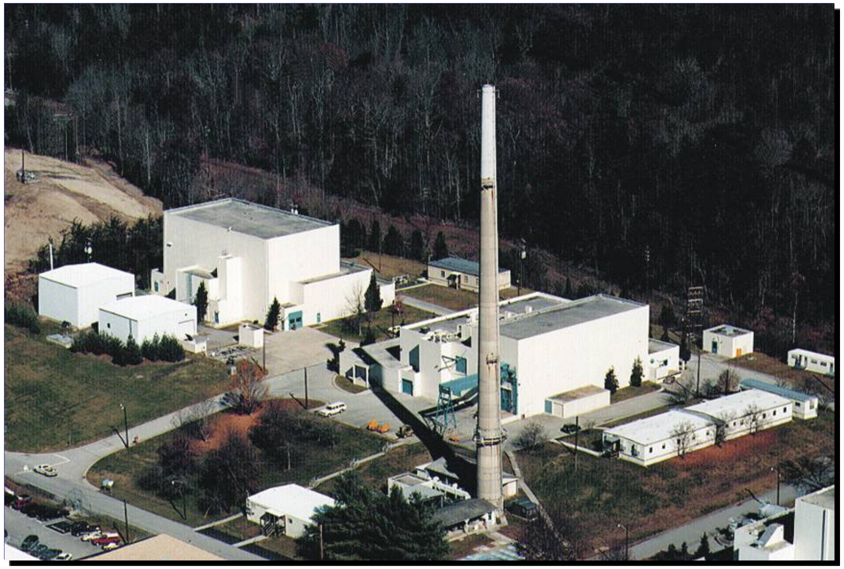
Product is plutonium dioxide powder with an isotopic content of Pu-238 greater than 80%.
Each production cycle converts 10-15% Np-237 to Pu-238 with remainder of Np recycled

ORNL Pu-238 Project Concept

- Install new equipment in existing ORNL nuclear facilities
- Neptunium storage remains at INL
- Np shipped to ORNL as needed
- Target fabrication, ORNL laboratories
- Irradiations at HFIR and ATR
- Pu processing, ORNL hot cells
- Pu product shipped to LANL







1.5 kg Pu-238 Average Oxide Production per year

Inventory Management Considerations

- Pu-238 selection and processing
  - Source - domestic versus Russian
  - Assay – thermal power specifications for customer systems
  - Purity – impurity limits may require additional processing
  - Form – ease with which material can be rendered usable
- Pu-238 supply considerations
  - Continual evaluation of projected user needs
  - Need for and timing of new production
  - Potential future purchases from Russia
- NE coordinates with other programs routinely to ensure any excess programmatic materials can be put to good use