



Isotope Management for Space and Defense Power Systems

1st Workshop on Isotope Federal Supply and Demand

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January 11, 2012



U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

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 nearly 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

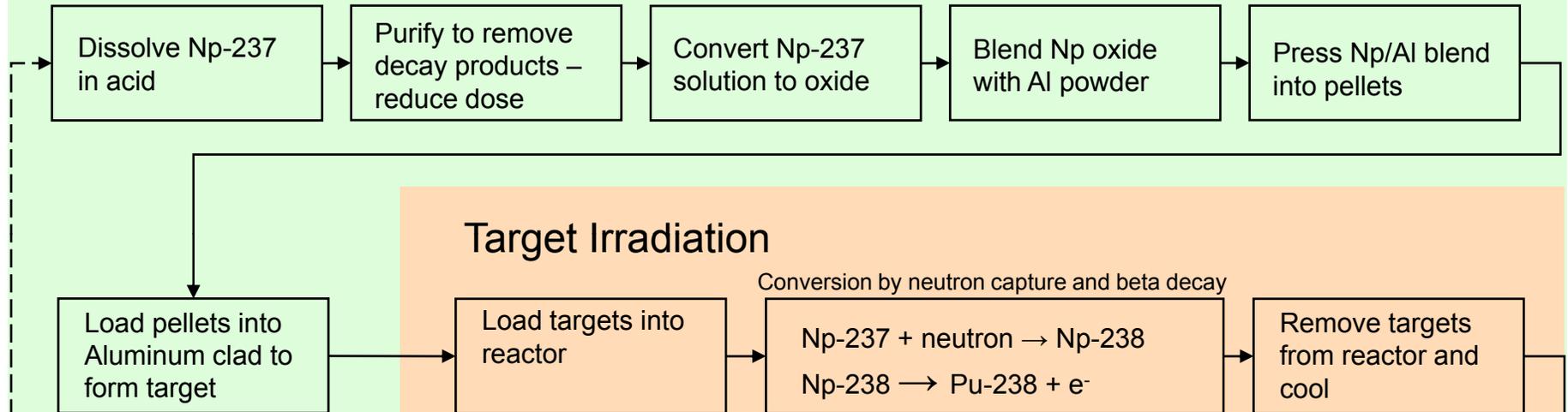
- Historically, Pu-238 was produced at Savannah River Site using Pu-239 production reactors and chemical processing facilities
- Production ceased in 1988 due to downsizing of the DOE nuclear weapons complex
 - Last remaining SRS operating reactor, K-Reactor, shut down in 1996
 - 1992 decision to phase 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
- National security requirements for Pu-238 currently being met from existing domestic inventory
- NASA requirements for Pu-238 being met by purchases from Russia
- Any future Pu-238 production would require alternate irradiation source and chemical processing capability

Current Plans for Pu-238 Production

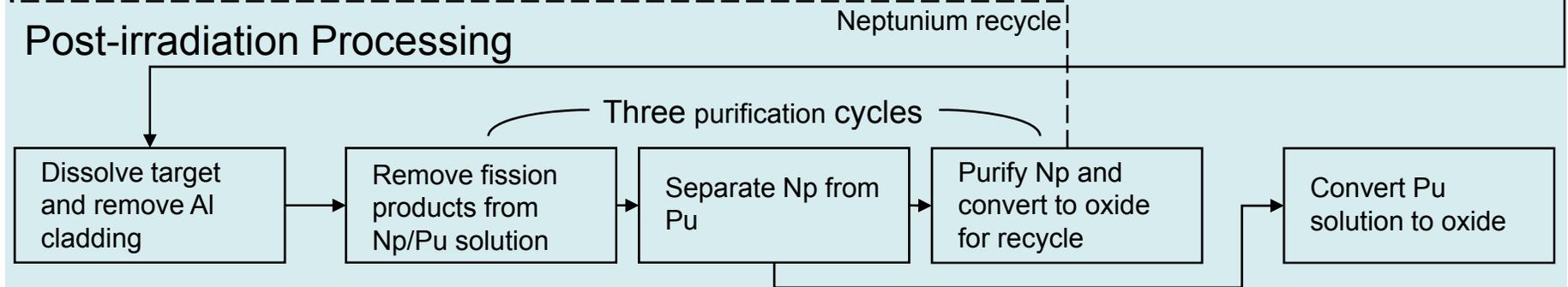
- DOE and NASA submitted shared funding requests in FY 2011 and FY 2012. To date, Congress has only funded NASA's share.
- Pu-238 Supply Project being initiated with NASA funds in FY 2012
- Planned production capacity is up to 2 kg/year
 - Would support NASA's current projected needs through 2030
 - National security needs to be met with existing inventory for foreseeable future
- Required production level can be met with existing, operating isotope separations facilities at ORNL
 - Other facility options will be examined as part of the capital acquisition process – cost, schedule and technical risk
- Target irradiation will be conducted in existing reactors (ATR and HFIR)

Pu-238 Production Process Flow

Target Fabrication



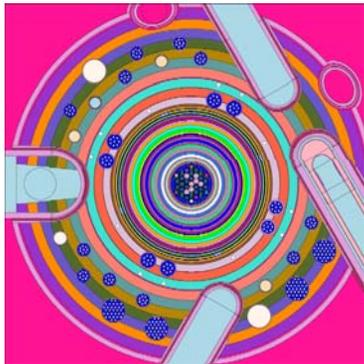
Post-irradiation Processing



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 in 3-6 kg shipments as needed
- Target fabrication, ORNL laboratories
- Irradiations at HFIR and ATR
- Pu processing, ORNL hot cells
- Pu product shipped to LANL



1-2 kg Pu-238 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