Future Supply of $^{238}\text{Pu}$ for Radioisotope Power Systems

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Many Manufacturing and Assembly Activities Are Required for Radioisotope Power Systems

- Graphitics
- Aeroshell GIS
- GPHS Assembly
- RTG Assembly
- Converter
- INL
- ORNL
- LANL
- Plutonium Fuel Production
- Stored Np
- Target Fabrication
- Irradiation ATR/HFIR
- Processing
- Pellet
- Launch
\( ^{238}\text{Pu} \) was Supplied Using the Weapons Production Infrastructure at SRS

- Irradiation of neptunium oxide mixed with aluminum powder in aluminum clad targets to produce \( ^{238}\text{Pu} \) (~6 vol.% NpO\(_2\))
- Target fabrication was based on larger (~3” O.D., ~12’ long) targets that were designed for K reactor, a heavy water moderated \( ^{239}\text{Pu} \) production reactor
- Reactor target volume allowed large batches of \( ^{238}\text{Pu} \) to be made in a single campaign (~12 kg batches)
- H-canyon was used for recovery of \( ^{238}\text{Pu} \) as product and \( ^{237}\text{Np} \) for recycle
- K reactor has been shut down; weapons production halted
- Restarting production will require use of existing reactors and infrastructure
# Reactor Characteristics Desired for $^{237}$Np Conversion to $^{238}$Pu

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Desired to maximize $^{238}$Pu</th>
<th>Desired to minimize $^{236}$Pu impurity</th>
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</thead>
<tbody>
<tr>
<td>Neutron spectrum</td>
<td>High thermal flux</td>
<td>Minimize high energy flux$^1$</td>
</tr>
<tr>
<td>Photon spectrum</td>
<td>Large diameter</td>
<td>Minimize high energy flux$^2$</td>
</tr>
<tr>
<td>Target size</td>
<td>Maximize loading</td>
<td>Small diameter</td>
</tr>
<tr>
<td>Neptunium loading</td>
<td>Minimize loading</td>
<td>Minimize loading</td>
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</tbody>
</table>

**Notes:**

1. Increasing the water or other moderator content in the test position can augment natural high-energy neutron flux suppression in a thermal reactor.
2. High energy photon flux can be suppressed by avoiding or minimizing materials with high energy photon yields and reduced by incorporating photon shielding materials in the test position.
Cross Section of DOE Reactors Showing Irradiation Facilities

Cross section of the INEEL/Advanced Test Reactor depicting irradiation facilities

Capsule irradiation tank
“B” hole
Fuel assembly
Neck shim rod
“H” hole
“IA” hole
Flux trap capsule facilities
Safety rod

“OA” hole
Loop irradiation facility
Outer shim control cylinder
“I” hole
Capsule irradiation tank

High Flux Isotope Reactor (HFIR)
Target Design has Stepped Through 3 of 4 Phases

**Dosimeter Targets**

- $^{236}$Pu Content of Unperturbed Reactor Flux
- Characterize ATR
- Neutron and Gamma Spectral Influence on $^{236}$Pu

**Pellet Targets**

- Influence of Pellet NpO$_2$ Loading on $^{236}$Pu
- Demonstrate Pellet Performance

**Array Targets**

- Examine Influence of Multi-Target Self Shielding on $^{236}$Pu Impurity Data on Fission Gas Product Release from Pellet Matrix

**Prototype Targets**

- Prototype Manufacturing Methods
- Target Quality Control
A Processing Flowsheet for $^{238}$Pu Recovery was Developed to Optimize Throughput and Minimize Footprint

**Challenges:**

- Design targets; fabricate and irradiate ~500 targets/year
- Optimize or enhance existing chemical processing equipment to recover needed quantity of $^{238}$Pu
- Product purity of recovered materials and purification
- Waste disposition
REDC Hot Cells Have Unique Processing Capabilities

Facilities contain laboratory, glove box, and engineering-scale hot cell facilities.

Hot cells were designed to handle alpha, beta-gamma, and neutron-emitting radionuclides.

Process equipment in place to dissolve, separate, recover and purify heavy element products and dispose of fission product wastes.

Fully remotely operated and maintained.

In-house analytical chemistry to support isotope production, process development, and R&D activities.

Currently operating with approved DOE Category 2 Safety Basis.
Summary of Analyses to Date Show That $^{238}$Pu Supply Can be Met with Existing Facilities

- $^{238}$Pu supply of 1.5–2kg can be met with existing reactors and hot cell facilities
- $^{236}$Pu content will be higher than historical values
- Target development and preparing for irradiated target processing should proceed as rapidly as possible
QUESTIONS?