Plutonium Immobilization Project Review

For NW Technical Review Board

Augusta, GA.

December 17, 1997

Tom Gould

Lawrence Livermore National Laboratory
Westinghouse Savannah River Co.

Pu Immobilization Topics

Plutonium Immobilization Project

- **Description of immobilization form and process**
- **Form development, characterization, and performance testing**

Candidate Pu Materials for Immobilization

Plutonium Immobilization Project

	Pu Mass, MT
Clean metal (incl. pits)	32.8
Impure metal	2.4
Plutonium alloys	1.0
Clean oxides	1.7
Impure oxides	6.4
U/Pu oxides	0.9
Alloy reactor fuel	3.5
Oxide reactor fuel	1.3
Total plutonium	50.0
Total uranium	16.6

Plutonium Ceramic Immobilization Form

- **Formulation goal: accommodate Pu, U, and neutron absorbers along with expected feed material impurities within well characterized and highly durable mineral phases**
- **Titanate mineral phases chosen for their high durability in nature and their ability to accommodate actinide elements**
  - **Primary phases are pyrochlore, zirconolite and brannerite**
  - **General formula: $A^{(+2)}B^{(+4)}Ti_2O_7$ where A = Ca, Gd; B = Hf, Gd, U, Pu**
- **Composition of key elements (percent)**

CaO	10.0
HfO_2	10.6
PuO_2	11.9
UO_2	23.7
Gd_2O_3	8.0
TiO_2	35.8

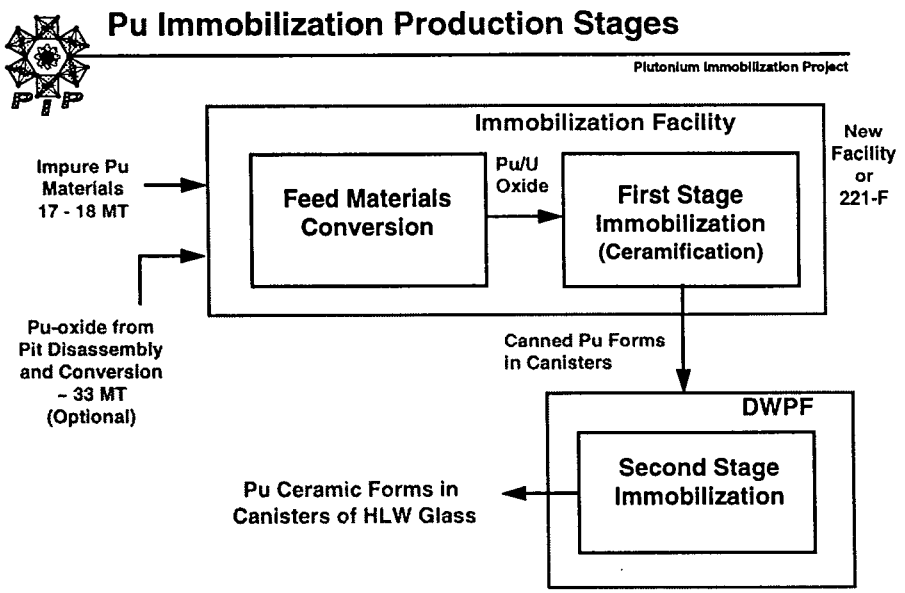
Can-in-canister Immobilization Form

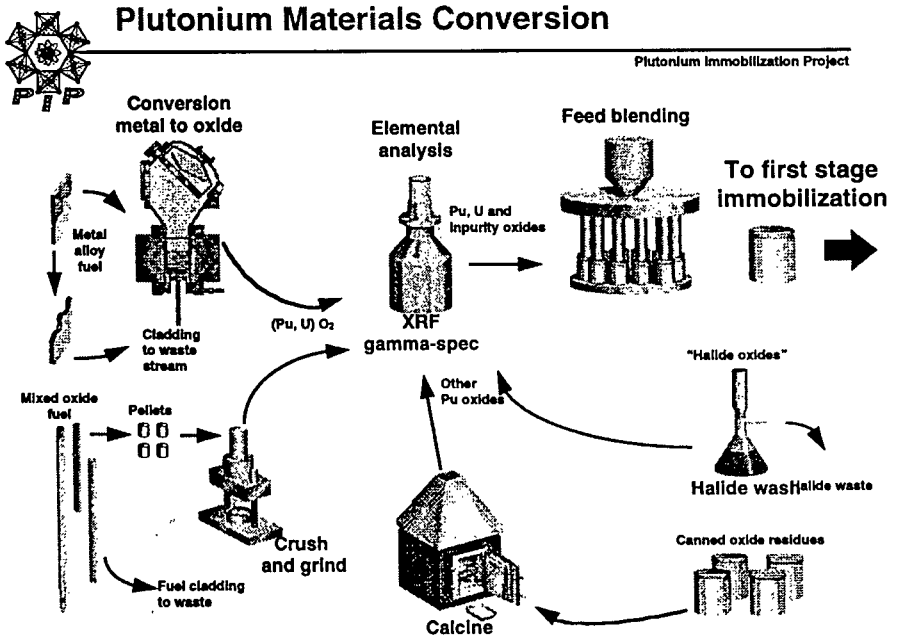
- **Pu ceramic form (pellet)**
  - **2.625" dia. by 1" thick**
  - **~ 51 g of Pu**
  - **Density of 5.5 g/cc**
- **Canned ceramic forms**
  - **21" high by 3.0" OD**
  - **20 pellets**
  - **1.02 kg Pu / can**

Canned Ceramic Pellets

- **Can-in-canister form**
  - **28 cans in 7 columns**
  - **28.6 kg Pu / canister**
  - **~ 12% vol. displaced**
- **Number of Pu canisters**
  - **"17" MT case: 635 (77 extra)**
  - **50 MT case: 1744 (210)**

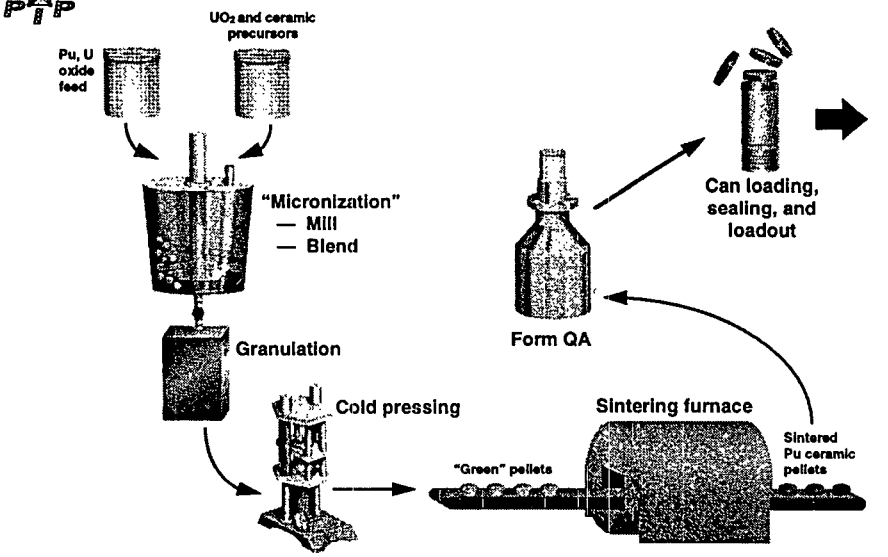
Can-in-canister Form


Pu Immobilization Production Stages
Plutonium Immobilization Project
Immobilization Facility
New Facility or 221-F
Impure Pu Materials 17 - 18 MT
Feed Materials Conversion
Pu/U Oxide
First Stage Immobilization (Ceramification)
Pu-oxide from Pit Disassembly and Conversion ~ 33 MT (Optional)
Canned Pu Forms in Canisters
DWPF
Second Stage Immobilization
Pu Ceramic Forms in Canisters of HLW Glass


Plutonium Materials Conversion
Plutonium Immobilization Project
Conversion metal to oxide
Elemental analysis
Feed blending
To first stage immobilization
Metal alloy fuel
Cladding to waste stream
(Pu, U) O2
Pu, U and inpurity oxides
XRF
gamma-spec
Mixed oxide fuel
Pellets
Other Pu oxides
"Halide oxides"
Halide wash
Halide waste
Crush and grind
Fuel cladding to waste
Canned oxide residues
Calcine

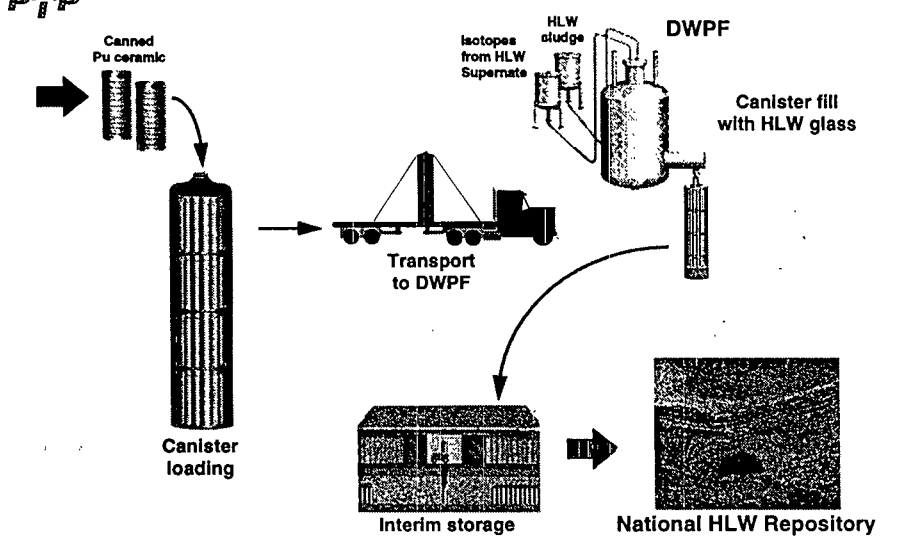
First Stage Immobilization - Pu Ceramic Formation

Plutonium Immobilization Project



Second Stage Immobilization (DWPF)

Plutonium Immobilization Project



Development Program Summary

Plutonium Immobilization Project

- Characterize Pu feed materials
- Determine compositional envelope of ceramic form and phase relationships for expected range of feed compositions
- Develop production process flowsheet and determine acceptable range of processing parameters (t, T, atmosphere, etc.)
- Develop prototypes for and test key equipment components
- Finalize design of can-in-canister form
- Demonstrate can-in-canister form/process with actual materials at SRS
- Perform durability tests and analytical studies to predict behavior of form under repository conditions
  - Ensure against nuclear criticality post closure

Form Performance Testing & Evaluation

Plutonium Immobilization Project

- Test form's durability under simulated repository conditions
  - Intrinsic corrosion behavior under static (saturated) and dynamic (unsaturated) ground water conditions
  - Corrosion behavior in presence of HLW glass/canister alteration products
- Characterize secondary phases formed by alteration of form and determine the partitioning & holdup of fissile elements and neutron absorbers
- Develop thermodynamic data of key elements for long-term performance modeling
- Develop analytical model to predict form degradation under range of possible repository conditions
- Evaluate effects of radiation damage on form performance