Treatment Options for Aluminum SNF Disposition

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Nuclear Waste Technical Review Board
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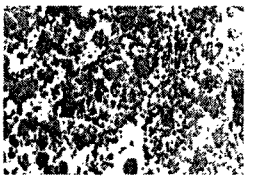
Metallurgy and Corrosion Alternate Aluminum SNF Treatment Technology Outline

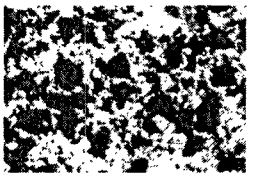
- Aluminum Spent Nuclear Fuel
  - Background
  - Corrosion Performance in Wet Storage (Initial As-Received Condition)
  - Corrosion Performance in Dry Storage
- Proposed Path Forward
  - Direct/Co-Disposal
  - Dilution Technology - Melt-Dilute Form

Aluminum MTR Fuel Microstructures

As-Fabricated UAlx MTR Fuel

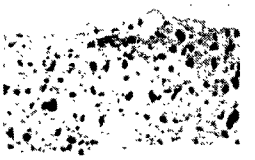


As-Fabricated U3O8-Al Fuel

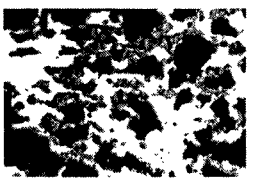


As-Fabricated U3Si2-Al MTR Fuel

Aluminum MTR SNF Microstructures



Irradiated UAlx MTR Fuel

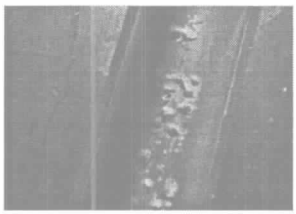


Irradiated U3O8-Al Fuel

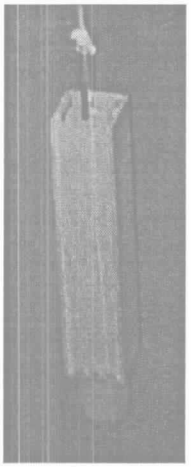
Irradiated U3Si2-Al MTR Fuel

Corrosion Performance of As-Received Aluminum SNF

- Key to Corrosion Performance
  - Environmetal Condition
  - Integrity of the Oxide Layer
- Reactor Service
- Basins of Origin
- SRS RBOF and L Basins



SNF with Pitting Corrosion
Worst Case SNF Condition - FRR Receipts Program
Total Pitted Area: < 1% SNF Surface

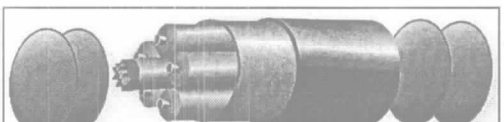


MTR SNF After 25 Years Wet Storage

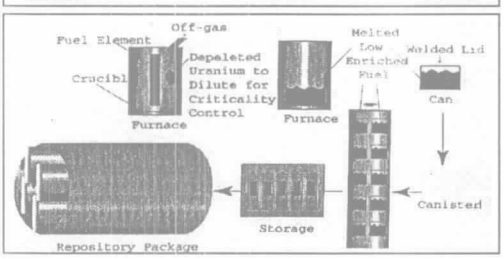
Alternate Aluminum SNF Treatment Technology

- FY97
  - SRS Initiated Aggressive Implementation of Alternate Aluminum SNF Treatment Program
- Technology Development Program ⇨ Dual Track Approach

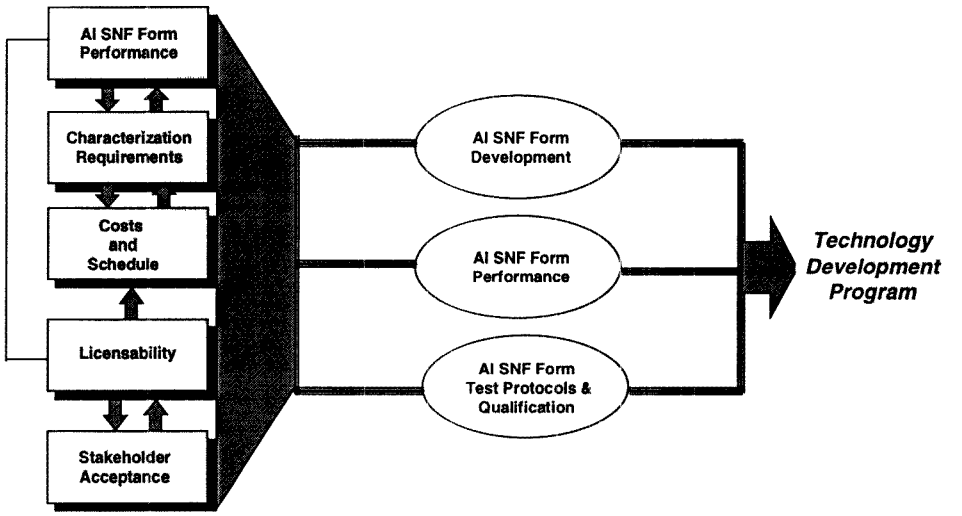
Direct Disposal



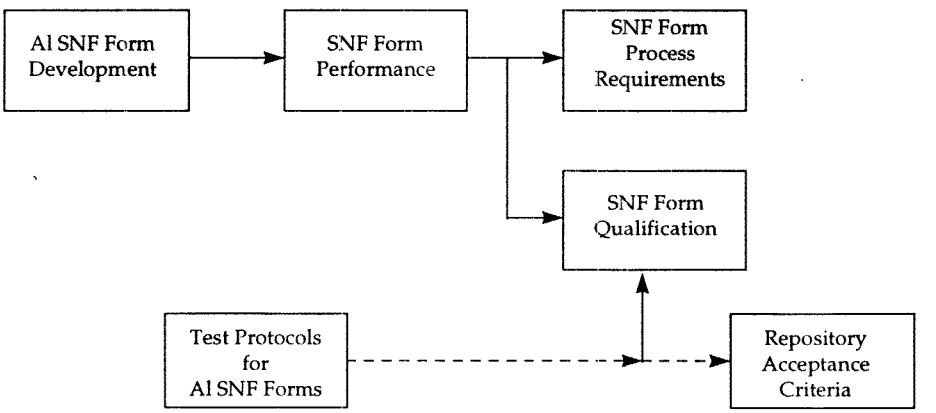
Dilution Option



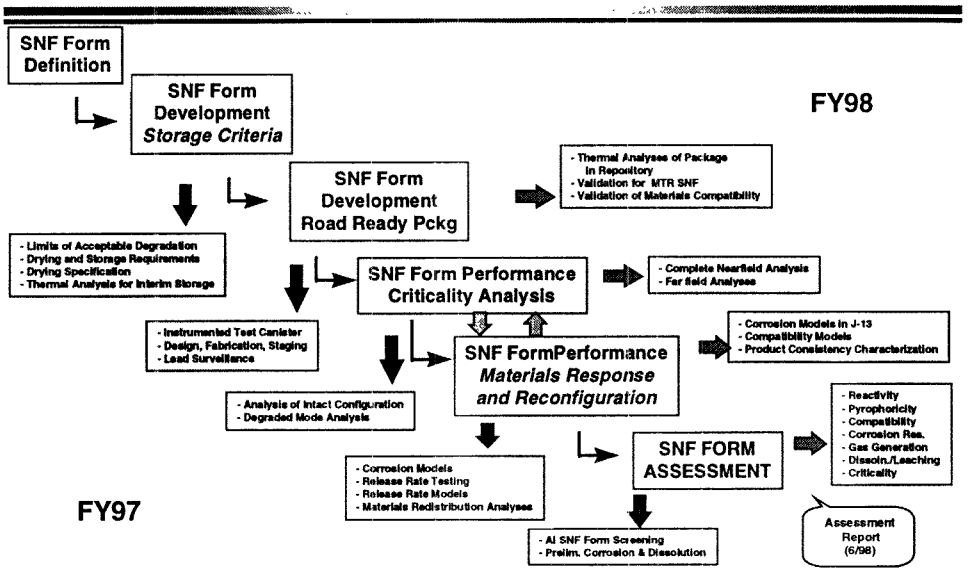
Alternative Aluminum SNF Treatment Technology
Technology Decision Drivers



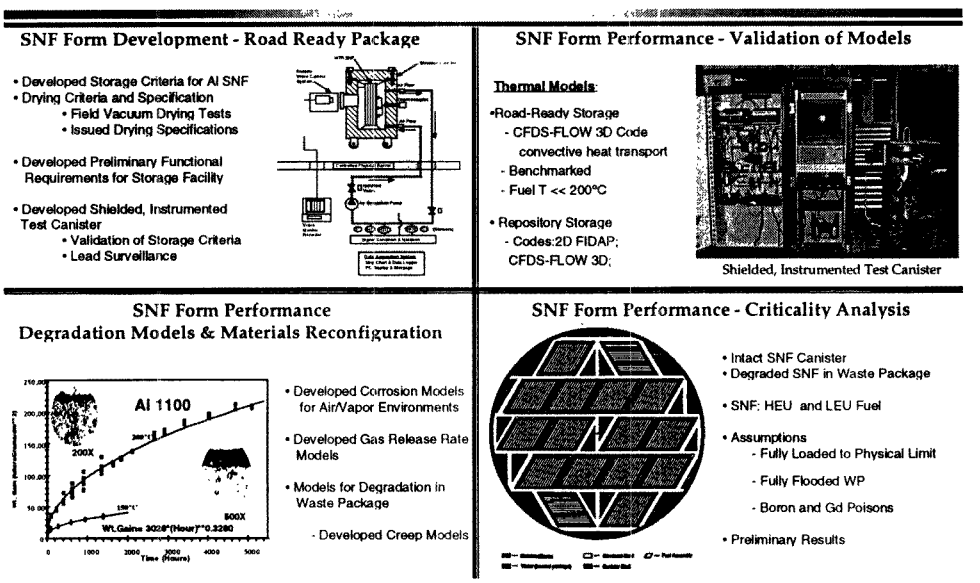
Aluminum SNF Form
Development and Qualification



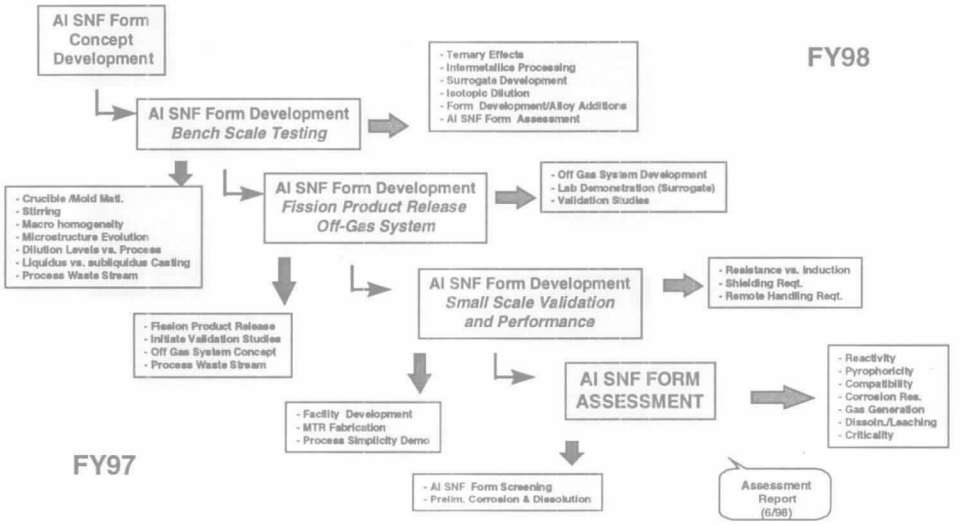
Direct Disposal/Co-Disposal Technology Development



Direct Disposal Accomplishments

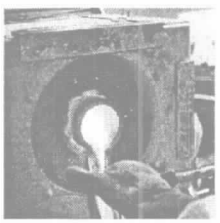


Melt Dilute
Technology Development



Melt-Dilute Waste Form
Accomplishments

Al SNF Form Development - Bench Scale

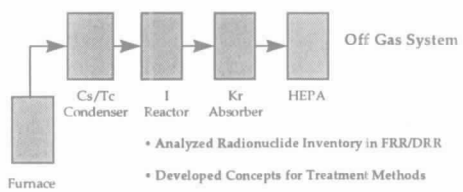


- Developed Bench Scale Apparatus
- Established Process Feasibility
  - Induction vs. Resistance
  - Induction vs. Mechanical Stirring
  - Evaluated Crucible Materials
  - Evaluated Dilution Levels
  - Evaluated Process Cycles

Al SNF Form Development
Volume Reduction as *f* (Process Options)

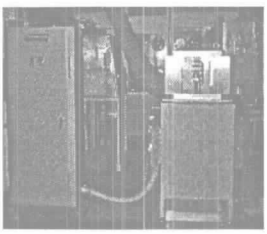
Additions	Uranium	Uranium and Aluminum		
Alloy Wt%	2 - 67%	13%	30%	67%
# of Canisters				
20% Dilution	253	396	283	320
5% Dilution	272	1234	479	326

Al SNF Form Process Requirements



- Analyzed Radionuclide Inventory in FRR/DRR
- Developed Concepts for Treatment Methods
- Analyzed Process and Secondary Waste Stream

Al SNF Form Development -Small Scale



- Developed Resistance Furnace for M-D of Full Scale MTR
- Demonstrated M-D with Full Scale Dummy MTR
- Designed Induction Furnace for Full Scale MTR

Aluminum SNF Form Testing

Al SNF Form Testing in Aqueous Environments

- Glass Waste Form => Release of Radionuclides
  => Tests in Aqueous Environment
- Commercial SNF (UO_2) => Release of Radionuclide
  => Dissolution Tests

"Homogenous Dissolution"

- HEU Al SNF
  - Release of Radionuclides
  - Materials Reconfiguration

"Heterogeneous Dissolution"

Test Protocols for Al SNF Form

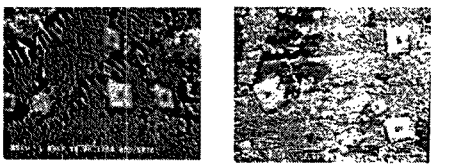
- A Test or Series of Test to Characterize Al SNF Form
  - Model after ASTM Standard for Waste Package
  - Corrosion by Water Intrusion
    - Aqueous and Vapor
  - Release of Radionuclides
  - Role of Environmental Variables
    - including co-disposal configuration
  - Extent of Transport
- ASTM Standard Guide or Standard

Test Methods for Al SNF Form

Release of Radionuclides:

- Dissolution Tests => Flow Tests and Drip Tests
- Corrosion Tests => Anodic Polarization, Cyclic Polarization, Electrochemical Noise
- Static Dissolution Tests and Vapor Phase Tests

Dissolution Characteristics - Preliminary Data



- Microstructure Dependent
- Preferential Dissolution: Al > UAl_3 > UAl_4

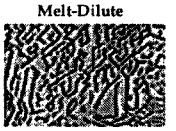
Al SNF Form Characteristics

SNF Form Stability

Direct Disposal

Irradiated MTR - Al + UAl_3+UAl_4

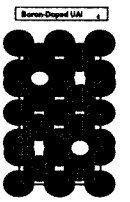
Melt-Dilute



Al+ UAl_4

Corrosion Resistance of Al+ UAl_4 > Al+UAl_3+UAl_4
M-D SNF Form: Tailored Microstructure

Al SNF Form Characteristics - Criticality



- Poisons Necessary for Direct Disposal
- Poisons If Necessary in Melt-Dilute Form will be Integral to Structure
  - Boron Forms Compounds of U or UAlx
  - Efficacy of Boron f(Degradation Rate)

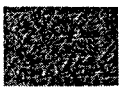
Al SNF Form Stability - Radionuclide Release

Radionuclide Release => f (Inventory, Retention Mechanism)

D-D

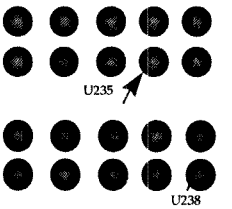
- Fission Gases in Pores
- Fission & Activation Products Partitioning Between UAl_3, UAl_4 and Al

M-D



- No Fission Gases
- Fission & Activation Products Partitioned to UAlx

Al SNF Form - Proliferation Resistance



- Isotopic Dilution to <20%
- Liquid Phase Processing
- No Ready Separation of U235