SAND2010-4489P

FY11 Storage and Transportation R&D Planning

Meeting with BAM, SNL, INL, NRC

July 13, 2010

Baltimore, Maryland

R&D Opportunities Focus

Objectives:

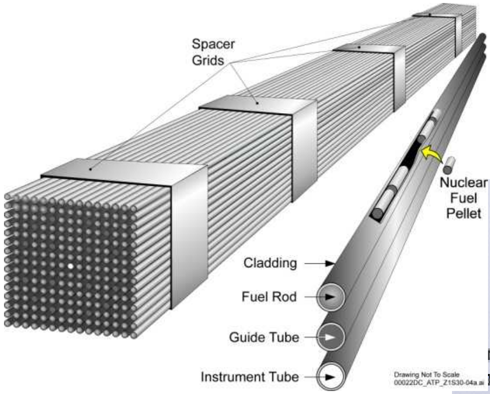
- Develop the technical bases to demonstrate used fuel integrity for a storage period of up to 300 years.
- Develop technical bases for fuel retrievability and transport after long term storage.

Tasks

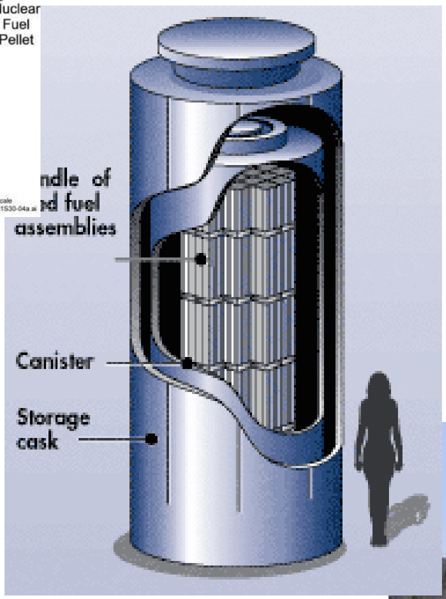
- Identify major storage system components
- Define functional requirements
- Identify mechanisms affecting VLTS
- Prioritize testing needs
- Conduct tests/analyses

Storage System Components

I. **Fuel**
   - I. **Pellet**
   - II. **Fuel/Clad**
   - III. **Assembly**



II. **Cask**
   - I. **Basket**
   - II. **Internals**
   - III. **Canister**
   - IV. **Overpack**



III. **ISFSI**
   - I. **Pad**
   - II. **Rebar**
   - III. **Physical Protection**

Functional Requirements

- Defined by:
  - Regulations
  - Regulatory guidance
  - Industry practice and experience
  - Programmatic requirements
  - Unforeseen requirements stemming from R&D investigations

Functional Requirements
(U.S. Focus - others to add)

- Regulatory Requirements:
  - 10CFR72
    - Allows for storage up to 120 years (60 yrs in-pool and 60 yrs dry storage)
    - Used fuel cladding must be protected against degradation that leads to gross failure
    - Must maintain confinement of intact and damaged used fuel
    - Must be retrievable
  - NUREG-1536 requires maintenance of;
    - Thermal performance
    - Radiological performance
    - Confinement
    - Sub-criticality
    - Retrievability

Functional Requirements

- Regulatory Guidance: Potential Issues*
  - Condition of fuel and basket in a sealed canister
  - Degradation conditions that could require repackaging…what are they and how are they expected to occur?
  - Repackaging at sites where reactor decommissioning has taken place
  - Required long-term monitoring
  - Aging management requirements
  - Effect of potential climate change
  - Influence of very long term storage on transportability
- Regulatory Guidance: Plan for storage for up to 300 yrs**

* Einziger, presentation at EPRI meeting; "Issues Related to Long-term Dry Storage of Used Nuclear Fuel", Nov 18-19, 2009.

** COMSECY-10-0007, Project Plan for the Regulatory Program Review to Support Extended Storage and Transportation of Spent Nuclear Fuel, June 15, 2010.

Functional Requirements

- Industry Experience: Technical issues addressed from past R&D program; [EPRI/INL/NRC Dry Cask Storage Characterization (DCSC) Project]
  - No cask functional degradation observed 15 years
  - Assemblies look the same
    - No sticking; no significant bowing upon removal
    - No visual signs of degradation
  - No leaks during storage
  - No significant additional fission gas release to rod internals
  - No significant hydride reorientation
  - No creep during storage
  - "Creep life" remains
  - Most severe conditions during first 20 years

→ <u>Challenge</u>: Demonstrate similar behavior for up to 300 years

Functional Requirements

- Industry Experience: What hasn't been addressed?
  - Effect of marine environment
    - Cannot rule out corrosion and stress corrosion cracking
  - Development of advanced cladding materials
  - MOX fuel
  - Long-term concrete degradation
  - High burnup fuel (>45GWD/MTU) Hydride reorientation
    - Hydride embrittlement
    - Creep
    - Plenum gas pressure
    - Corrosion

→ Challenge:
Demonstrate mat'l degradation behavior for high burnup used fuel over a long storage period.

Functional Requirements

- Programmatic Requirements
  - Support industry and regulators in;
    - Identifying technical gaps related to long-term storage of used fuel for up to 300 years.
    - Develop plan for addressing these gaps
    - With industry (and regulator input), conduct research needed to address the technical gaps
    - Develop the technical basis for very long term storage of used fuel
    - Develop the technical basis for retrievability and transport of used fuel after long term storage
  - Engage the international community in this effort

Identify mechanisms effecting VLTS

- A Features, Events, and Processes (FEPS) methodology is used to identify degradation mechanisms

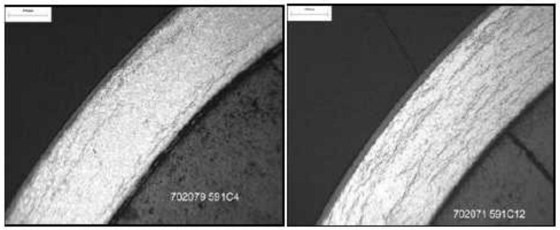
Systems analyzed: → **Topics investigated for each system:**

Fuel/clad system
Fuel assembly
Hardware
Baskets
Neutron Poisons/Shields
Container
Over pack
Pad
Monitoring, security, institutional control

Goes back to Functional Requirements:
Thermal
Radiation
Confinement
Criticality
Retrievability/Transportation

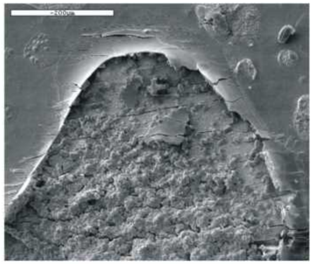
Early list of identified technical gaps based on Functional Requirements and FEPS analysis

- Fuels
  - Hydride re-orientation
  - Hydride embrittlement
  - Plenum gas pressure
  - Corrosion
  - Creep



Hydride Orientation in Clad

- Casks
  - Seals
  - Bolted and welded closures
  - Neutron shields
  - Concrete degradation



Seal Corrosion,
D. Wolff, et al., PATRAM 2004

- Cask Systems
  - Concrete degradation
  - Salt atmosphere (coastal environments)

Provisional List of Data Needs

	Fuel	Internals/Canister	Overpack/ISFSI	Transportation
Germany				
Japan				
United Kingdom				
United States	• Hydride re-orientation • Hydride embrittlement • Corrosion • Creep	• de-watering effectiveness • stress corrosion cracking (marine environments) • Neutron poison degradation	• Concrete degradation (marine environments) • Closure lids and bolts	• Fuel retrievability • Clad integrity of high burnup fuel after storage • Kinetic energy transferred to fuel from normal condition loadings (e.g., 1-meter drop)

Data Acquisition

	Destructive Examination	Non-destructive Examination/ Analysis	Accelerated Aging Applications	Aging Management Plan
Fuel	PIE (hot cell) • Hydride reorientation • Hydride embrittlement • Corrosion	Physical measurements • Creep	High burnup fuel • Hydride reorientation • Hydride embrittlement • Corrosion • Creep • Fuel modeling and analysis	• Limit excursion temperatures/time during dry loading?
Internals/ Canister	• Marine environment stress corrosion cracking • Neutron poison mat'l metallography/examination		• Stress corrosion cracking	• Mitigative measures for SCC in marine environments
Overpack/ ISFSI		• Visual inspections		• Concrete inspection and repair • Closure lid/bolts inspection and repair
Transportation	• Measure internal KE from a 1-meter drop test	• Model and analyze fuel response to a 1-meter drop test (incorporate findings from corrosion, hydride degradation and KE inputs to analysis)		