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Fuel Cycle Technologies Program

ASME SETTING THE STANDARD

NUPACK
May 10, 2011

Argonne NATIONAL LABORATORY | Idaho National Laboratory | ornl OAK RIDGE NATIONAL LABORATORY | Pacific Northwest NATIONAL LABORATORY | SRNL SAVANNAH RIVER NATIONAL LABORATORY

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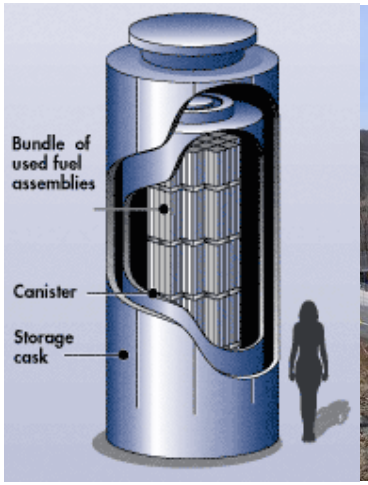
U.S. Department of Energy Nuclear Energy Fuel Cycle Technologies Program

- **Key Program Objective**
  - Develop options for used nuclear fuel management

- **FCT Program Structure**
  - Advanced Fuels / Transmutation systems
  - Separations / MPACT
  - Systems Analysis / Engineering
  - Modeling and Simulation
  - Used Fuel Disposition



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Used Fuel Disposition Campaign

- **UFD Campaign Mission**
  - **Identify alternatives and conduct research & technology development to enable storage , transportation, and disposal of used nuclear fuel generated by existing and future nuclear fuel cycles.**

- **UFD Campaign Baseline**
  - **Storage, transportation, and ultimate disposal.**
  - **Includes legacy LWR used fuel and new waste streams from alternative fuel cycles.**
  - **Includes NRC- and DOE-licensed sites.**
  - **International collaborations.**

Used Fuel Disposition Campaign

- **Work Packages: Multi-National Laboratory**
  - **R&D Opportunities**
  - **Transportation**
  - **Security**
  - **Concept Evaluations**

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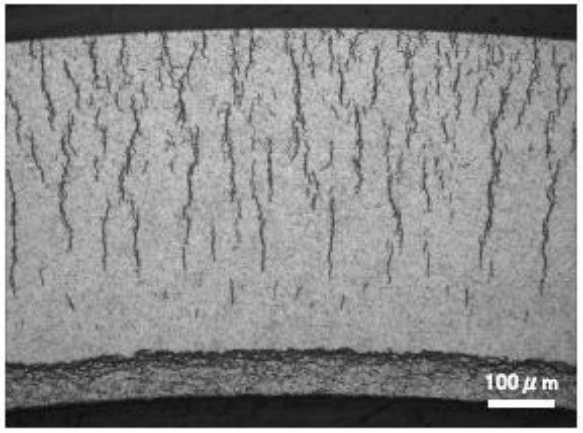
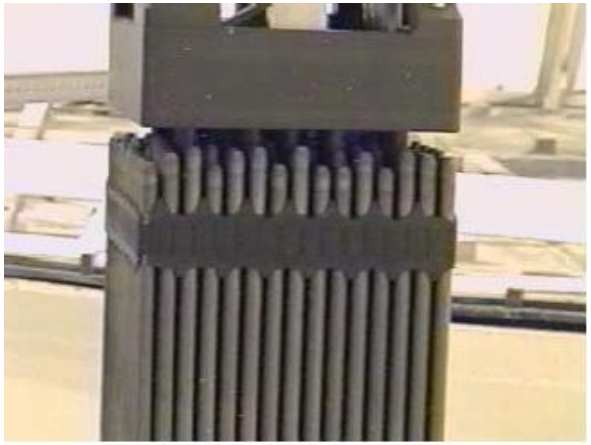
UFD Objectives

- 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 transportation after long-term storage.
- Develop the technical basis for transportation of high burnup fuel.





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UFD Storage

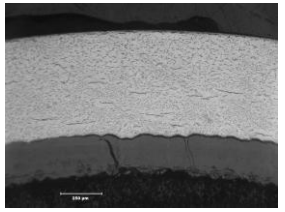
How to resolve very long-term storage technical issues ?

R&D Opportunities
- Data gap analysis
- Plan to address gaps
- Development of technical bases

Security
- Identify issues peculiar to long-term storage

R&D Facility Conceptual Evaluation
- Development of technical basis

Transportation



Focus on long-term storage of LWR fuel

UFD Storage Implementation Plan Goals

1 yr: Project Implementation Plan Framework
5 yr: Project Implementation Plan & Development of Technical Basis
10 yr: Field operating project

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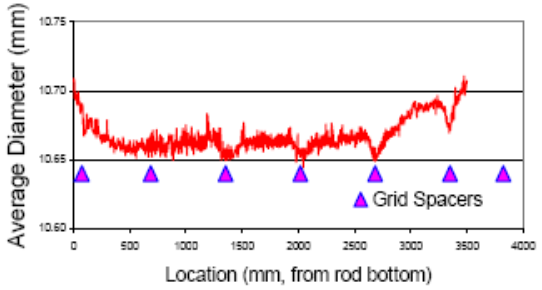
UFD R&D Opportunities
Identify potential degradation mechanisms

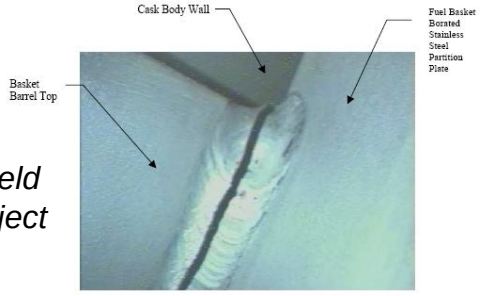
Identify all potential degradation mechanisms that may impair long-term storage and subsequent transport of used fuel

- **Systems to be analyzed**
  - **Fuel / clad system**
  - **Fuel assembly**
  - **Baskets**
  - **Neutron Poisons / shields**
  - **Container**
  - **Overpack**
  - **Pad**
  - **Monitoring; security**

INL Dry Storage Characterization (DSC) Project



Creep data from DSC Project



BSS basket weld from DSC Project

Storage
Regulatory Requirements

10CFR72

NRC rulemaking to allow for storage up to 120 years (60 yrs in-pool and 40 + 20 years dry storage).

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

1. **Thermal performance**
2. **Radiological performance**
3. **Confinement**
4. **Sub-criticality**
5. **Retrievability**

Storage
Industry Experience

Technical issues addressed from past R&D program
[EPRI/DOE/NRC Dry Cask Storage Characterization (DCSC) Project at INL]

- 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
- Most severe conditions during first 20 years?

→ **Challenge:**
Demonstrate similar behavior for up to 300 years

Storage
What hasn't been addressed?

- **Effect of marine environment**
  - ***Cannot rule out corrosion and stress corrosion cracking***
- **Advanced cladding materials and assembly designs**
- **MOX fuel**
- **Long-term concrete degradation**
- **High burnup fuel (>45GWd/MTU)**
  - ***Hydride reorientation***
  - ***Hydride embrittlement***
  - ***Creep***
  - ***Plenum gas pressure***
  - ***Corrosion***

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

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UFD R&D Opportunities
Storage preliminary assessment

System	Issue	Importance of R&D
Cladding	Annealing of Radiation Embrittlement, Oxidation, Creep	Medium
	H_2 Embrittlement, Hydride Cracking	High
Container (Welds, Bolts, Metal Seals)	Humid Oxidation, Marine Environment, Wet Corrosion	High
	Temperature Fluctuations Relax Metal Seals and Bolts	Medium
Monitoring Systems	Performance Confirmation	Medium

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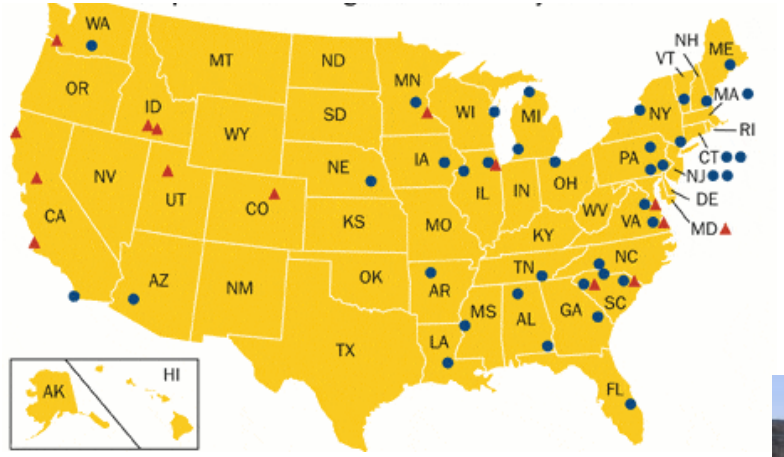
R&D Facility Concept Evaluation
Testing to evaluate aging of used fuel and storage systems

Potential demonstration project to develop technical basis for extended long-term storage



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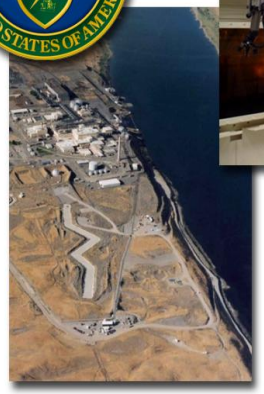
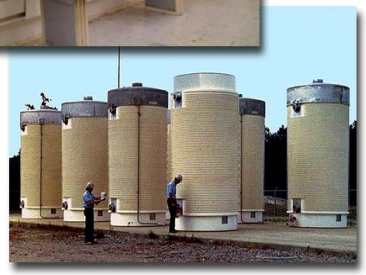
Testing & Evaluation Project

Options under consideration

Existing ISFSI

National Laboratory





Build demo facility

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Transportation

- **Identify transportation technical data gaps, including high burnup issues.**
- **Inventory used fuel to (eventually) be transported,**
  - **Inventory existing dual-purpose casks.**
- **Canister criticality analyses.**
- **Transportation test plan for normal-transport.**
- **Experimental program for irradiated cladding.**
- **Moderator exclusion justification.**

Canisters for all stored fuel?

- **Canisters preclude concerns about used nuclear fuel cladding degradation.**
- **Canisters ensure retrievability of used nuclear fuel after long-term storage.**
- **Canisters standardize loading and handling operations.**
- **Canisters could preclude criticality during transport if criticality-mitigation procedures are employed…**

…especially moderator exclusion.

Current storage of LWR Fuel

- **Surface storage at operating nuclear plants is usually in an ISFSI, licensed by NRC under 10 CFR Part 72.**
- **Commercial UNF in dry storage through March 2009**

	Casks	Assemblies	Metric Tons of Uranium
PWR	776	20,220	8,735
BWR	310	20,147	3,586
Total	1,086	40,367	12,321

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Casks used for dry storage

Total dry storage systems = 1404 **(as of 1 March 2011)**

- Metal casks = 182 (13%) Concrete overpacks = 1222

Metal casks = 182 (bare fuel = 170; with canisters = 12)

- **Bare-fuel metal casks**: all designed for transport.
  - *Most of the 170 have been stored beyond required maintenance period for transport (ANSI N14.5 annual leak test).*
  - 141 TN-32, -40, -68
    - *TN-68 has a current Part 71 certificate (certificate in review for TN-40).*
      - *(49 TN-68s in storage).*
  - 2 NAC-I28
  - 26 Castor V/21, X33
  - 1 MC10

Storage systems with canisters = 12 metal + 1222 concrete = 1234 **(88%)**

- **Metal casks with transportable canisters = 12**

  12 Holtec HI-STAR 100 casks (866 assemblies)

  HI-STAR 100 has a Part 71 certificate. HI-STARs in storage are beyond required maintenance period for transport (ANSI N14.5 annual leak test).

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Existing transportation casks
Topics for conversation

- **What is the existing USA transport cask fleet?**
- **What transport casks have been designed per Section III, Division 3? Storage casks?**
- **Transport of spent fuel to a centralized storage facility.**
  - ***The cask fleet may grow.***
- **How could we remove used fuel from BWR pools**
  - ***Either in an emergency or in a planned, near-term manner.***

NUPACK and National Policy

- **Are there any future NUPACK activities that could support the Very Long-Term Storage policy?**

Suggestions:

- **In-service inspection rules for storage casks.**
- **Maintenance guidance.**
- **Concrete storage systems.**
- **Canisters.**

NUPACK and the NRC

NUREG-1536, Rev1: 3.4.1.1 Steel Confinement Cask

"The structural design, fabrication, and testing of the confinement system and its redundant sealing system should comply with an acceptable code or standard such as ASME B&PV Code. (The NRC has accepted use of either Subsection NB or Subsection NC of Section III, Division 1 of this code.) **Division 3 of Section III** of the ASME B&PV Code, addressing storage of spent nuclear fuel, has been published, but ***currently no NRC position has been established on that standard***."

[*Note: NRC is reviewing applicability of NUPACK*.]

Blue Ribbon Commission on America's Nuclear Future

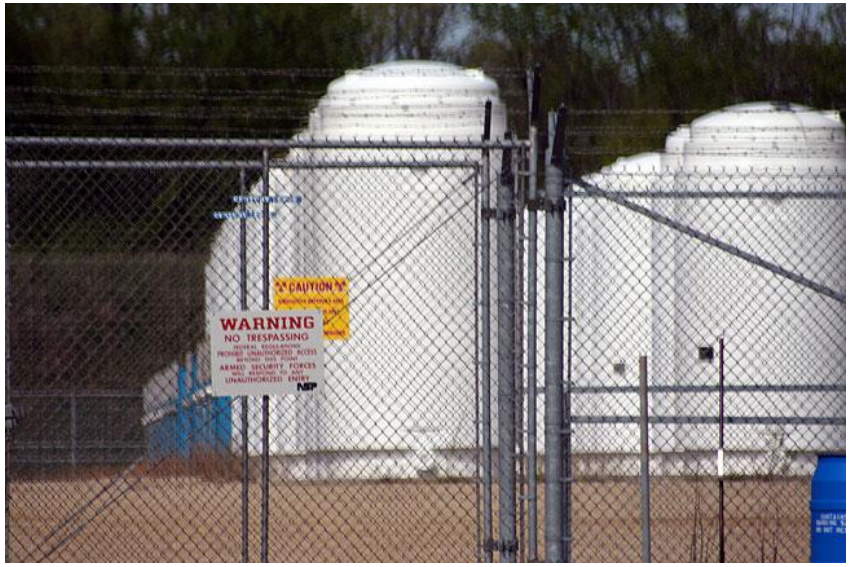
Potential recommendation?

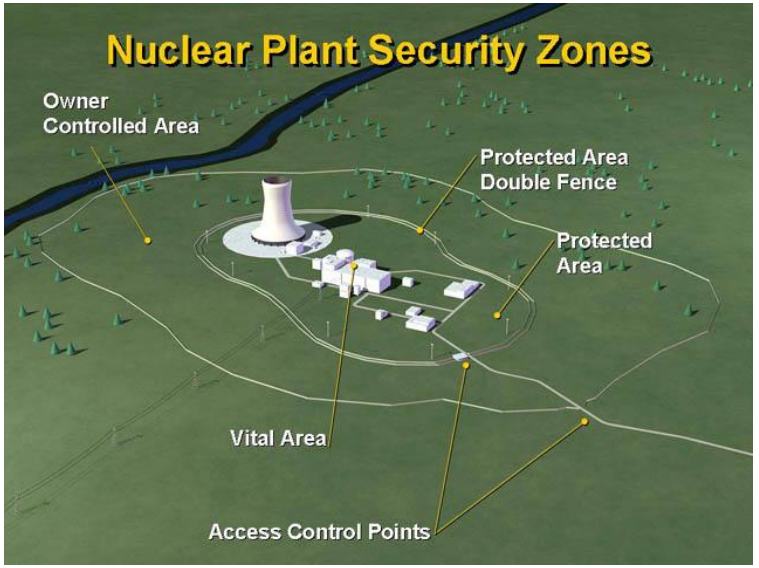
- **On-site, Centralized Storage**
  - **Decommissioned sites first**
  - **Security of decommissioned sites**
  - **Transportation to storage facility**
- **Spent fuel pools**

Draft report due July 2010

UFD: Security

- Identify security issues associated with long-term storage
  - E.g., consequences of going below the “spent fuel standard” of 100R/hr at 1 meter.
- Consider facility security integrated with aspects of cask/fuel design that contribute to security.





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Collaborative Activities

- **DOE/NE : *Program Direction & Management***
  - **DOE/RW, EM: E*xperience from related programs***
  - **National Laboratories: *Technical support for the technical work***

- **Industry/Technical Community/Vendors**
  - **EPRI *Extended Fuel Storage Collaboration Program (ESCP)***
  - **NEI *Dry Storage Information Forum***
  - **ASME**

- **International**
  - **BAM (Germany), CRIEPI (Japan), British Energy (UK/France), others**
  - **IAEA**
  - **INMM, PATRAM**

- **Nuclear Regulatory Commission: *supports collaborative efforts***

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UFD Campaign: Summary

- **DOE/NE is supporting development of the technical basis for certification of very long-term storage of used fuel.**
- **Development of a plan to support experimental data gathering to address gaps in the existing data base.**
- **Working with the NRC to properly integrate data needs.**
- **Working closely with industry and international partners.**