Status of Work Done to Date on Standard Canisters and Multi-Canister Overpacks

Presentation for Nuclear Waste Technical Review Board

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Outline

- NSNFP Role/Strategies
- Standard Canisters
  - Background and Design Objectives
  - Design, Analyses, and Testing
  - Transport and Moderator Exclusion
  - Other Open Issues
- Applicability Beyond Yucca Mountain
- Summary

Strategies for Management and Disposition of DOE-Owned SNF

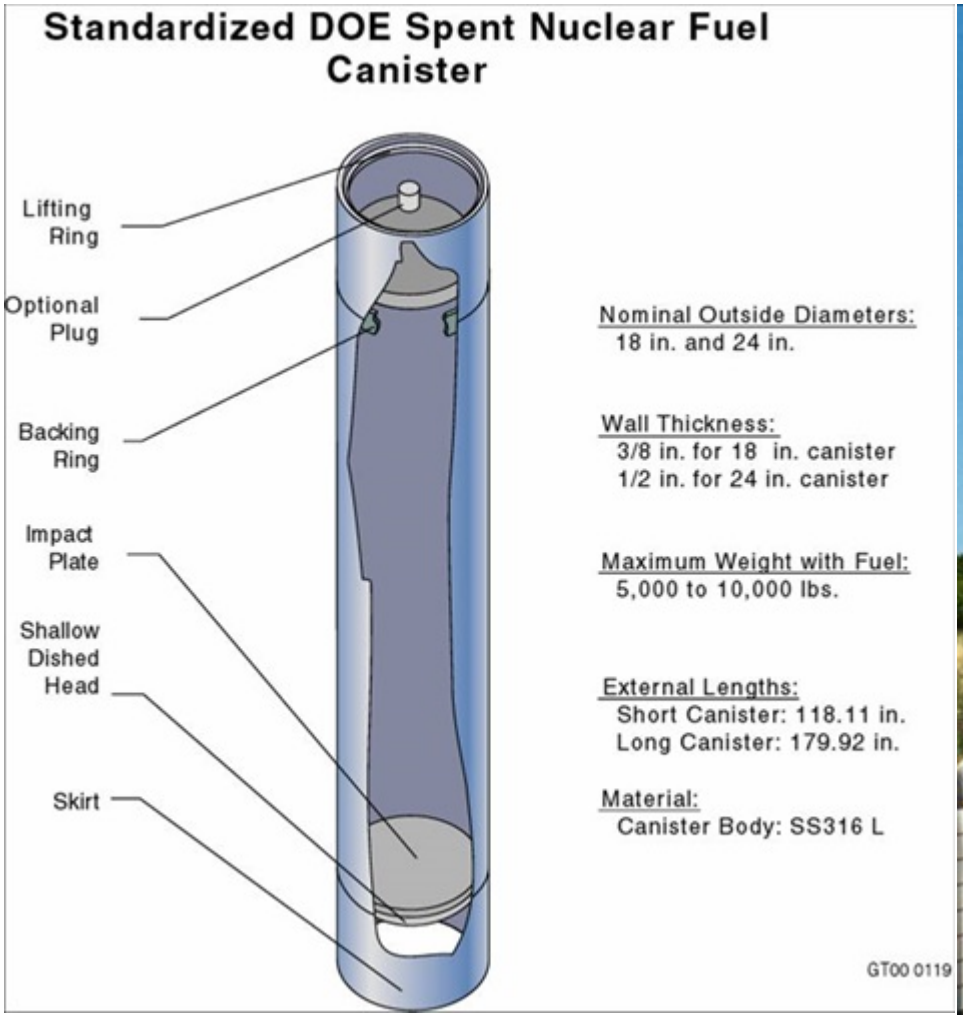
- Challenge
  - Diversity of DOE SNF
- Strategy
  - Shift safety basis from reliance on fuel-specific performance characteristics
  - Standardize equipment, operations, and analyses
- Approach
  - Fuel grouping
  - Bounding analyses
  - Standard canisters that perform safety functions
- Additional background and detail
  - DOE/SNF/REP-091, *NSNFP Activities in Support of Repository Licensing for Disposal of DOE SNF*, September 2004
  - Yucca Mountain Repository License Application, Section 1.5.1.3

Canister Design Objectives

- Standardize interfaces for handling DOE SNF
  - Simplify equipment design within and across facilities
  - Simplify handling of DOE SNF during interim storage, transportation, and disposal
  - Facilitate design and licensing for transportation and disposal
- Provide a high-integrity barrier to assure public and worker safety
  - Contain radiological material
  - Prevent intrusion of moderator

    Note: Unlike safety approaches that rely on properties of the SNF or its cladding, the canister is a barrier that can be designed, engineered, and tested to meet specified performance criteria.
- Preclude the need for any future repackaging
  - Avoid additional fuel handling operations
  - Reduce worker exposure

Standardized DOE SNF Canister



Cross-Section Showing Protective Features of Standardized Canister

Extensive Canister Analyses and Testing

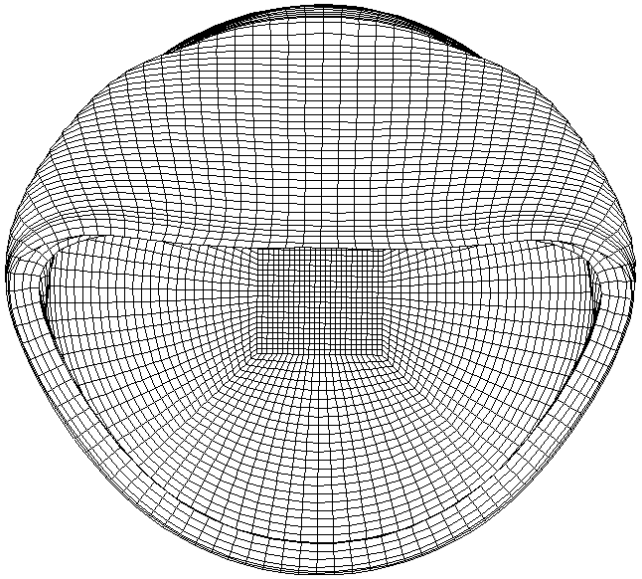
- Analytical modeling to predict stresses and strains
  - Analyzed for drop scenarios prescribed by 10 CFR 71.73 (i.e. transportation hypothetical accident conditions)
- Materials testing (static and dynamic) to confirm behavior
  - Critical flaw size and flaw propagation tests
  - Strain-rate effects
  - Temperature effects
- Full-scale drop testing to confirm canister performance
  - Drop tests also confirmed analytical predictions
- I've included a few pictures to illustrate some of the testing
  - There are many more pictures (and videos) available
  - Several additional references are provided in the last few slides

Extensive Canister Analyses and Testing

- Design concept demonstrated with full-scale testing of 18-inch and 24-inch standardized canisters at Sandia drop test facility
  - Completed nine drop tests (1999) with prototype standardized canisters
    - Drop heights per 10 CFR 71.73(c)
    - 30-foot drop onto an essentially unyielding horizontal surface
    - 40-inch drop onto a 6-inch diameter bar
  - Completed two drop tests with Idaho Spent Fuel Project designed standardized canisters and MCOs (2004)
  - Helium leak testing demonstrated leak-tight containment after drops on the most-damaged canisters
  - Deformations predicted by computer analysis matched actual results

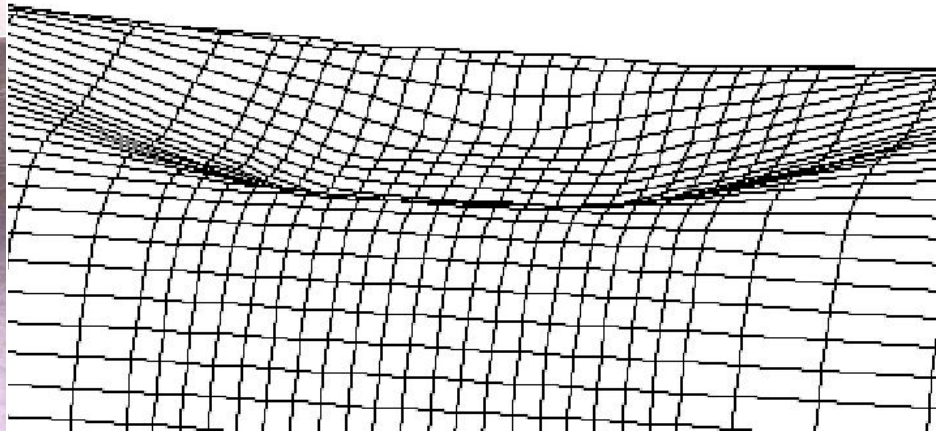
Full Scale Drop Testing

Actual Drop Test Match with ABAQUS / Explicit Model



30-foot drop at 45º impact angle

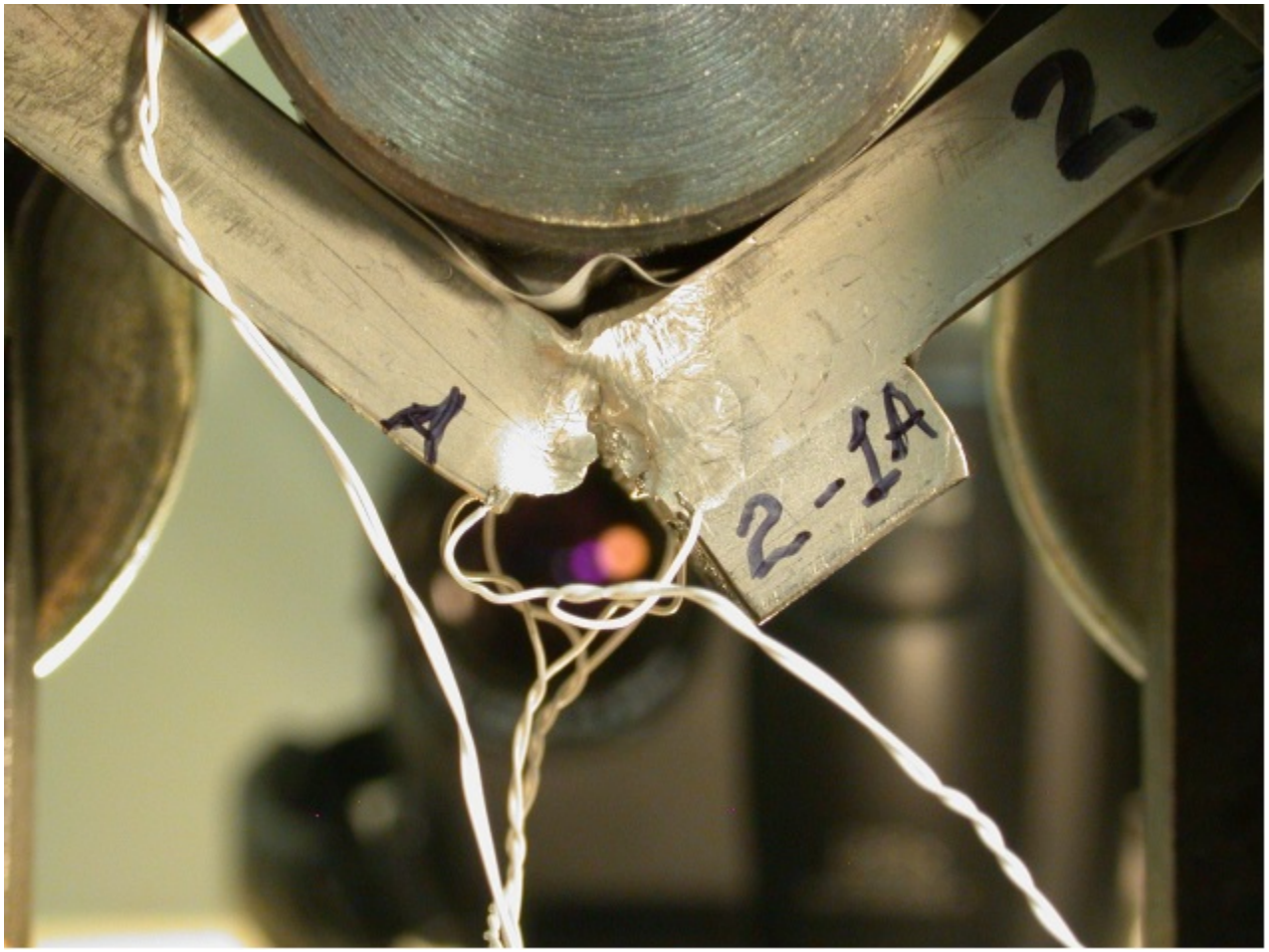
Actual Drop Test Match with ABAQUS / Explicit Model



Puncture test

40-inch drop onto a 6-inch diameter post

Flaw Propagation Tests



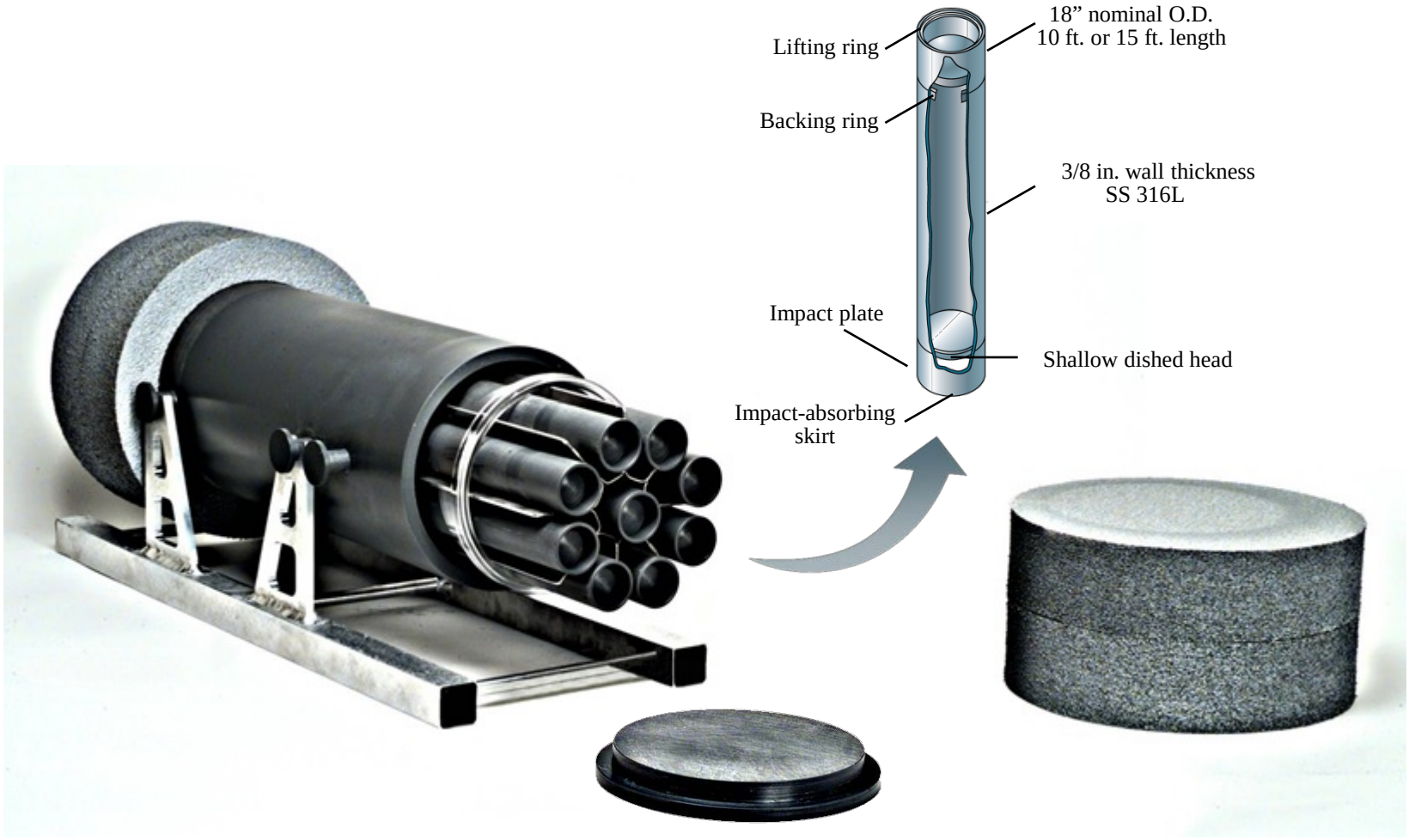
Use of the Standardized Canister

- Increases surety of operations
  - Relies upon engineered features designed and tested to meet the required performance standards
  - Standardizes operational equipment and procedures
  - Simplifies safety and regulatory basis
- Reduces overall risk
  - Eliminates the need for obtaining and justifying fuel-specific mechanical and chemical properties of diverse SNF types
  - Reduces reliance upon analyses with a wide range of uncertainty

Considerations Relative to an Undefined Endpoint, Path, and Storage Duration

- Packaging fuel into standard canisters allows essential safety functions to be shifted to a component that can be designed and tested to current requirements, inspected and maintained, and, if needed, repaired or replaced
- However, pre-maturely placing SNF into canisters may preclude options and/or result in sub-optimization
  - Commits to a canister loading and geometry in advance of repository waste acceptance criteria
- Challenges with DOE SNF are similar to those being considered with commercial SNF with respect to crediting cladding for safety functions over very long storage periods and for high burn-up fuel
  - Several references are provided regarding recent industry and NRC thinking related to crediting canister vs. cladding for key safety functions

Envisioned Transportation Package



Topical Report Background and Status

- Moderator exclusion provided by the standard canisters is the basis for pre-closure criticality safety in YMP LA
  - 10 CFR 63 is risk-informed
  - 10 CFR 71 is not

- In 2006, the NSNFP proposed a topical report requesting NRC approval to credit the DOE Standardized Spent Nuclear Fuel Canister for remaining leak-tight during the normal and hypothetical transportation accident conditions and the associated criticality analyses prescribed by 10 CFR 71.55

- Topical report status
  - Held 5 pre-application meetings from June 2006 through July 2007
  - Reached consensus on a path forward for completing and submitting the Topical Report
  - Due to subsequent events, this initiative was later put on hold

Topical Report Objectives

- Near Term …

  To confirm that DOE SNFs repackaged into DOE standardized SNF canisters will be acceptable for transportation

- Longer Term …

  To provide a starting point for an applicant to prepare an application for (or an amendment to) a certificate of compliance for a transportation package containing DOE SNF

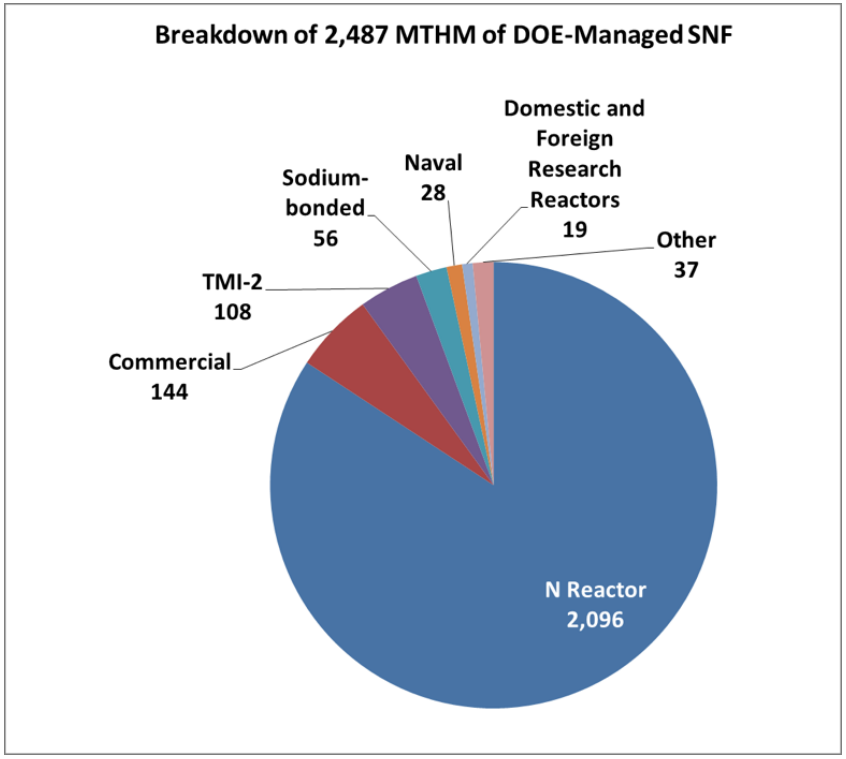
Transportation Safety Approach

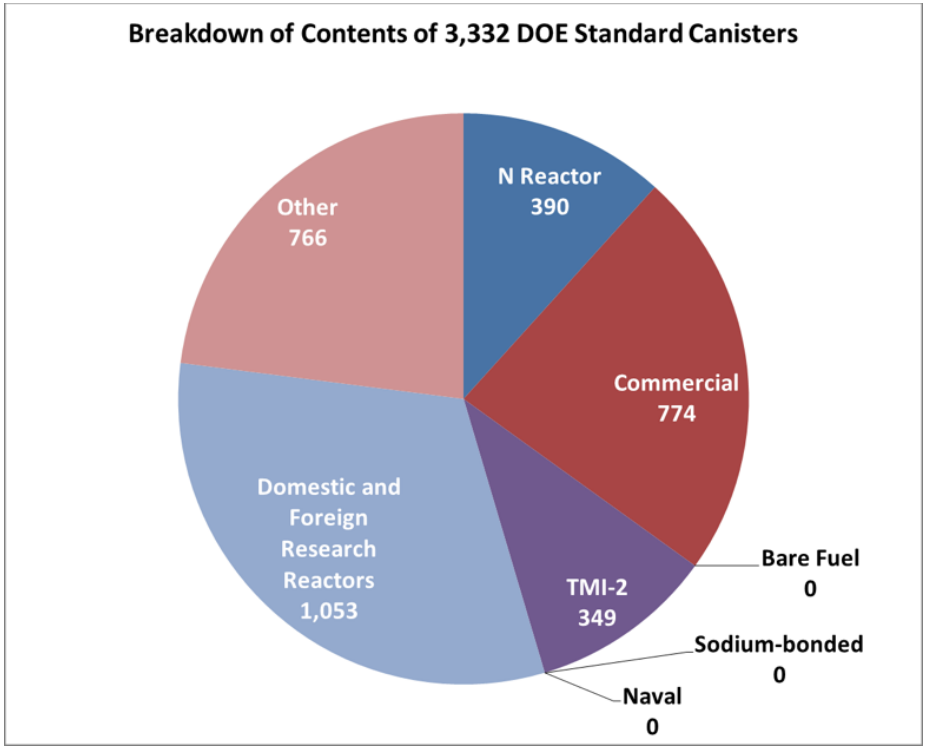
- Use standard transport cask(s)
  - Credit transportation cask for all containment, shielding, and other traditional cask functions
  - Specify cask interface requirements for keeping canister within its design envelope
- Demonstrate that …
  - All canister loadings are critically safe in their as-loaded configuration even with the non-mechanistic assumption of full flooding
  - Canisters will remain leaktight
  - All canister loadings are critically safe in their most reactive credible configuration with moderator by water to the most reactive credible extent (i.e. moderator exclusion) and with close full reflection by water on all sides

Standardized Canister Design History

- DOE-EM developed a preliminary design specification for the DOE Standardized Canister for DOE-EM site use
- DOE-ID contract for the Idaho Spent Fuel Project invoked the preliminary design specification
  - DOE-ID contractor prepared ASME Design Specification and design drawings for 18 and 24-in. diameter standardized canisters
  - Canister design has been reviewed and accepted by the NRC for storage (NRC License # SNM 2512 Docket No. 72-25)
- DOE-EM will make the Idaho Spent Fuel Project canister design documents available to other DOE sites for their use
- The as-designed canister has some minor modifications relative to the preliminary design specification
  - Changes are not expected to change conclusions of analyses and tests
  - Inclusion of a shield plug reduces canister volume and will thus impact the number of canisters needed

DOE Standard Canisters – How Many?





- The above canister counts presume no shield plug
- Yucca Mountain LA presumes 2,500 to 5,000 canisters

Technology Development: Canister Welding

Challenge

DOE standardized canisters must be seal-welded after loading with fuel in a high radiation environment. The closure weld must conform to ASME B&PV requirements.

Solution

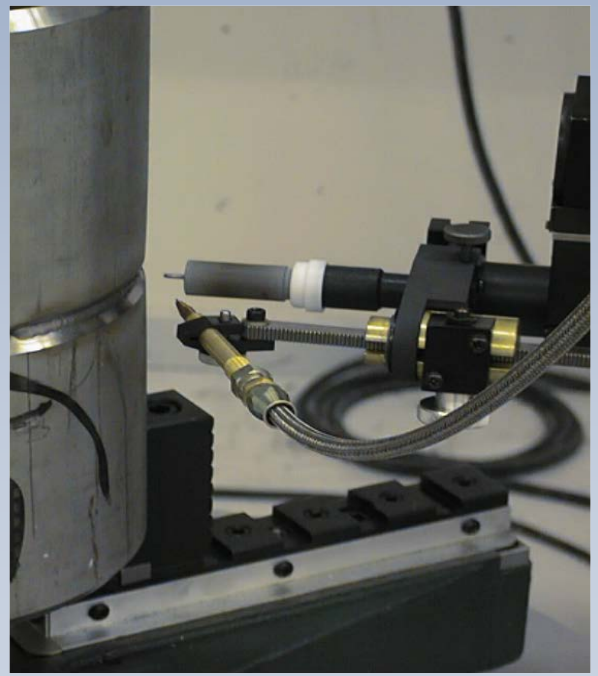
Canisters will be remotely welded and inspected to meet design requirements. Remote weld repair capability will be incorporated into system design.

Accomplishments

- ***System performance specification drafted***
- ***Demonstration weld system configured***
- ***Weld joint configurations evaluated***
- ***NDE performance parameters identified***
- ***Similar but much more complex waste package closure system developed and demonstrated at the Idaho National Laboratory***

Impact

Decreased number of SNF packages going to repository with reduced handling and materials costs. Radiation exposure to workers is de minimis. Significant life-cycle cost savings.



Technology Development: Advanced Neutron Absorber

Challenge

Some types of DOE spent nuclear fuel (SNF) contain highly enriched uranium. Final disposition of this SNF at the Yucca Mountain Repository requires criticality control over geologic timescales.

Solution

SNF will be stored in standardized canister with structural inserts fabricated from thermal neutron absorbing materials. Gadolinium is not preferentially leached from the waste in the disposal setting.

Accomplishments

- ***ASTM Material Specification B932-04 for Ni-Cr-Mo-Gd Alloy has been issued***
- ***ASME code case (N-728) for non-welded use completed***
- ***Criticality benchmark experiment completed and published***

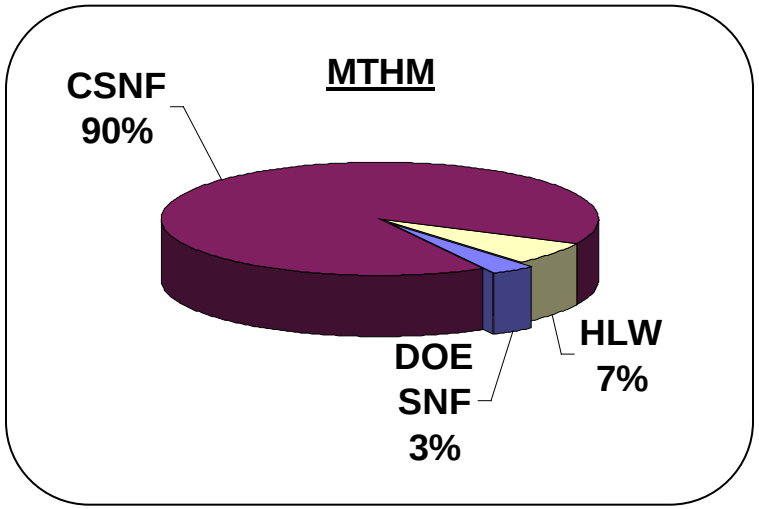
Impact

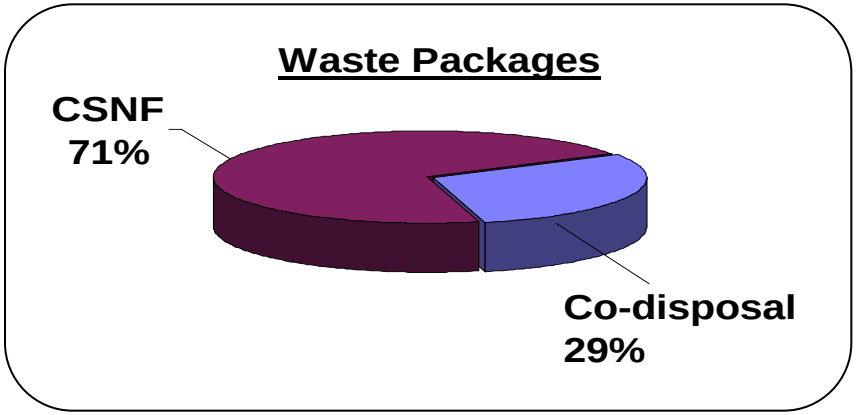
DOE SNF is critically safe under fully flooded and degraded conditions. Decreased number of SNF packages going to repository with reduced handling and materials costs.

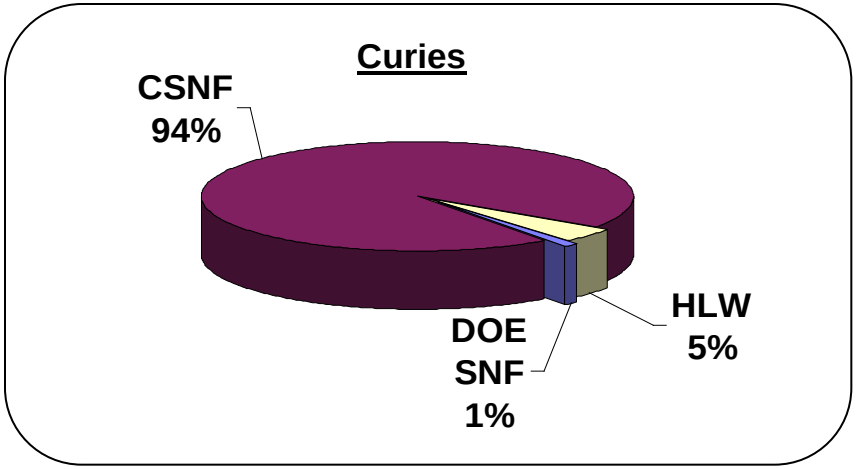
Beyond YMP……

- Storage, transport, and repository handling operations are independent of specific repository location or geology
- Conservatisms in Yucca Mountain post-closure analyses render much of the analyses to be independent of the repository
  - No credit is taken for the canister or fuel integrity after the waste package is sealed
  - Criticality safety presumed flooded, degraded waste packages
  - There is high confidence that DOE SNFs packaged consistent with the current repository safety bases will be acceptable for virtually any potential disposal scenario
- Evaluations of other repository geologies can be applied to DOE SNF
  - Virtually all repository concepts utilize a disposal overpack designed specific to the repository environment
  - DOE SNF contributes a relatively small portion of the heat load and dose

Comparisons of Repository Inventory







- DOE SNF is unlikely to challenge repository heat or dose limits
- DOE SNF just needs space in a repository

Summary

- Standard canisters are a robust storage solution with little risk relative to transport and disposal.
  - All repository concepts require a canister.
  - Analyses up until post-closure release are ‘repository-independent’.
- SNF will be packaged as aging facilities are retired. Will DOE be ready?
  - An NRC-acceptable strategy for transportation criticality safety should be achieved prior to loading and sealing standard canisters.
  - Neutron absorbers configurations need to be finalized for HEU fuels.
  - Fully remote closure welding will reduce canister count, personnel exposure, and costs.
  - Absent a final waste acceptance criteria, canister sizing and internal loading configurations cannot be ‘optimized’.
- National Spent Nuclear Fuel Program is gone.
  - Knowledge preservation and management are crucial.
  - Who owns and champions the DOE SNF management strategy?

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- Snow, S. D. et al., *Preliminary Drop Testing Results to Validate an Analysis Methodology for Accidental Drop Events of Containers for Radioactive Materials*, American Society of Mechanical Engineers Pressure Vessels & Piping Conference, ASME PVP-Vol. 425, July 2001.
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- Snow, S. D., *Design Considerations for the Standardized DOE SNF Canister Internals*, National Spent Nuclear Fuel Program, DOE/SNF/DSN-019, Rev. 1, March 2008.
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  - *Aging of DOE Standardized Canisters during Interim Storage*, Matt Ebner

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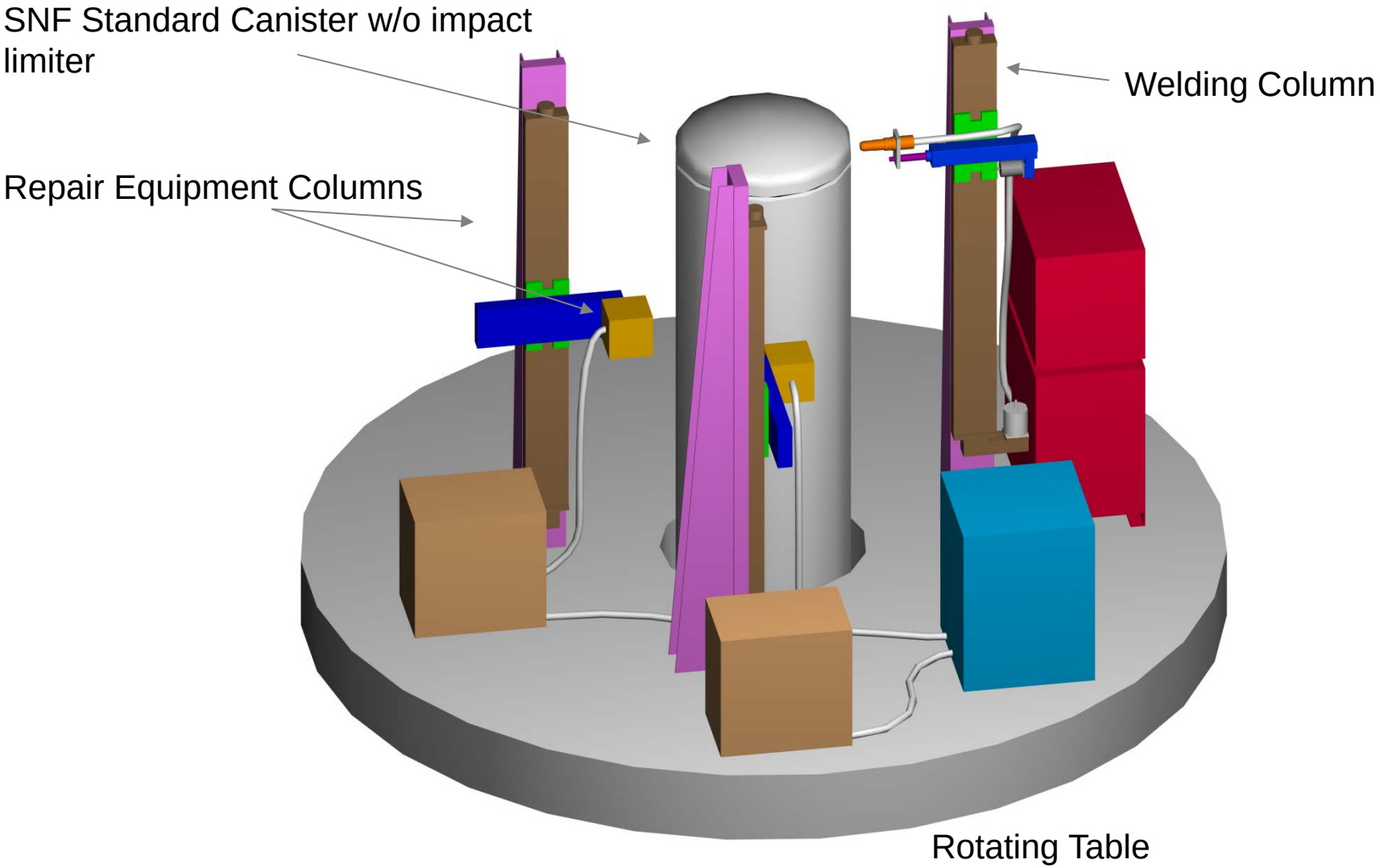
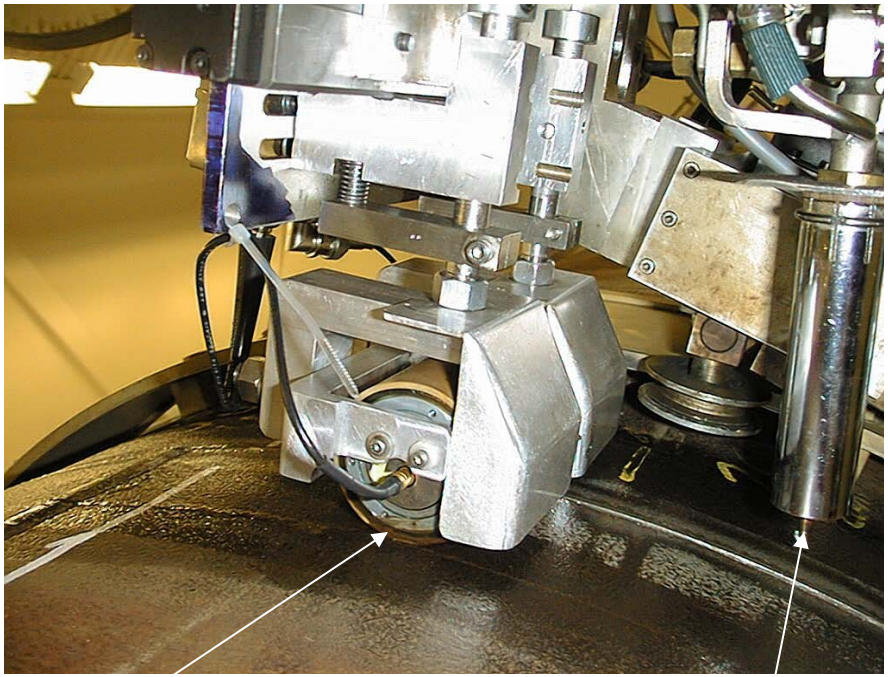
Supporting Slides – Remote Closure Weld Development

Canister Welding and NDE Equipment Concept

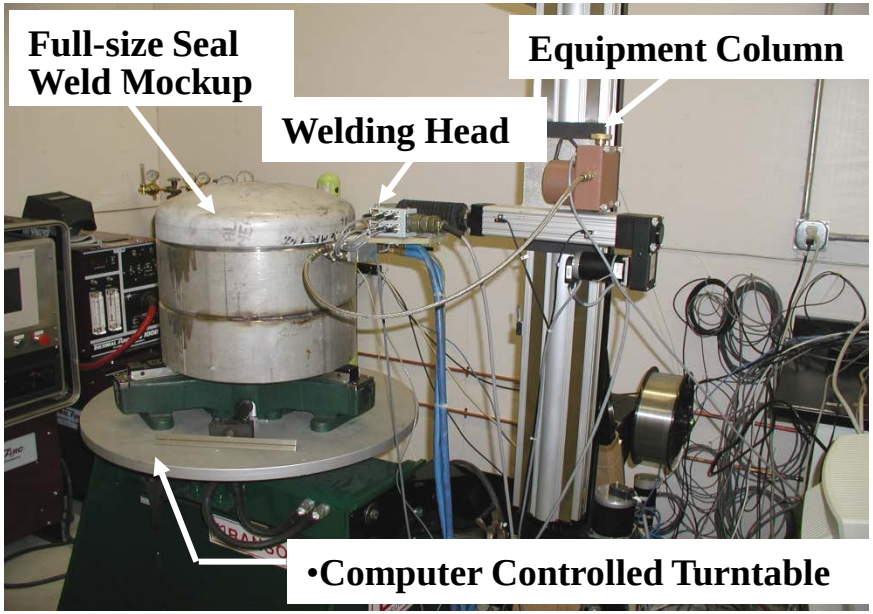


Developing remote welding and NDE capabilities



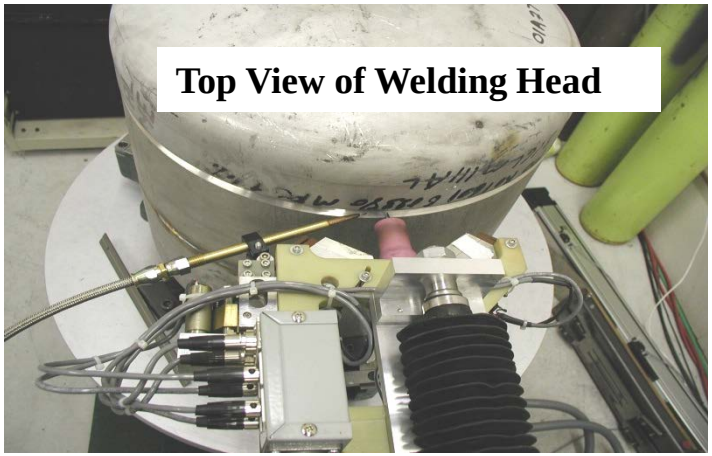
- *Needed for final closure welds in high-radiation fields*
- *Minimal heat input for welding and repair*
- *Provide full visual, surface, and volumetric inspection*
- *Real-time nondestructive examination*

Remote Welding & Repair

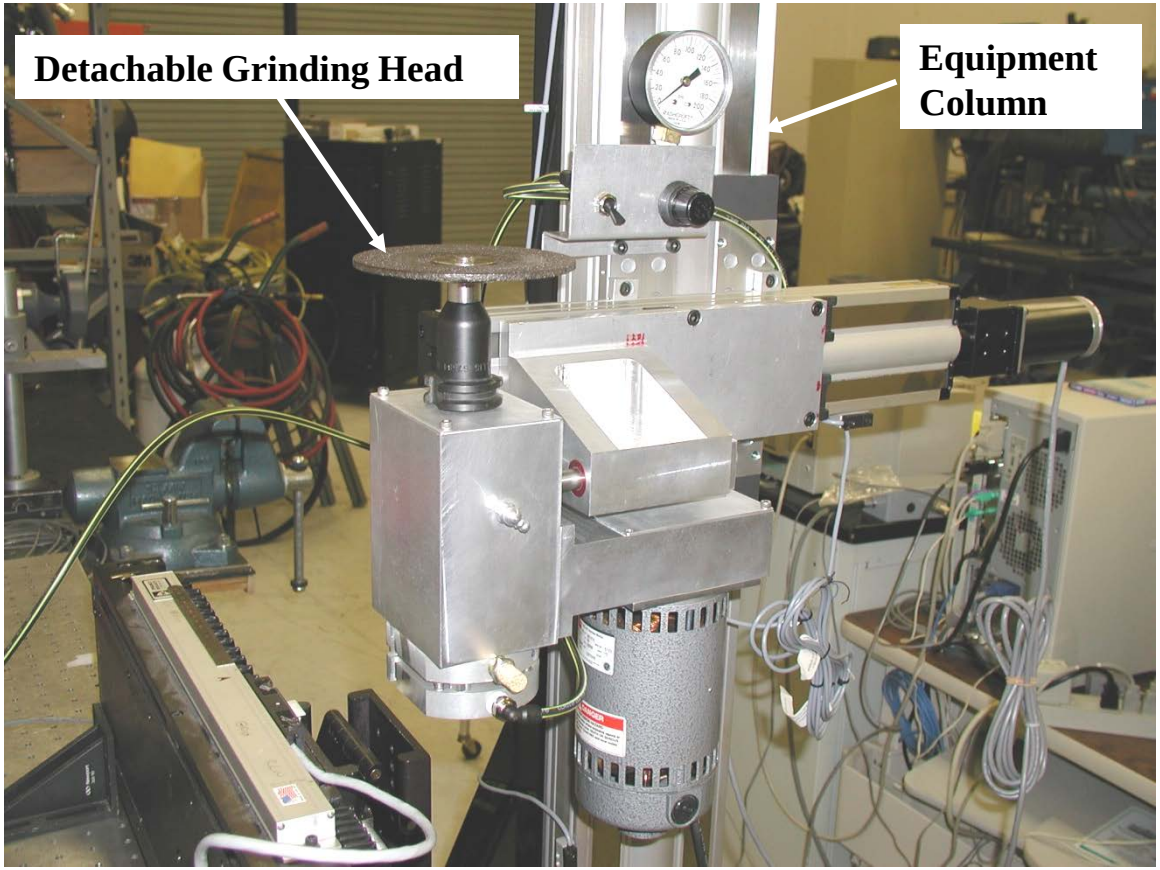


- Complete Integration with Repair and NDE Equipment
- Permanent Record Capability
- Only Minor Modifications Required for Different Field Applications

- Computer Controlled
- Low-Cost Power Supplies
- Remote Joystick Control
- Low-Cost Vision System with Complete Welding Arc Light Attenuation
- Independent Real-time Parameter Adjustment



Repair Equipment



- Remote Operation
- Computer Controlled
- Contour Weld Joint Grinding Capabilities
- “3-D” Manipulation
- 10,000 RPM
- 5 in. Diameter Disk
- Air-operated Detachable Detachable Head
- Contact Sensor
- Usage Sensor
- Integrated with Other Weld and NDE Equipment

NWTRB Questions

1. What is the status and what are the general characteristics of each type of multi-purpose canister and how many of each type are expected to be used for DOE SNF? (Slides 4 thru 12, and 20)
2. How does the storage container interface with any transportation overpack? (slides 15 thru 18)
3. Which modes of transportation (truck, rail, barge or some combination) can be used and would any specialized transportation infrastructure be needed? (slide 15)
4. Is additional design, testing, and analysis needed before the containers can be transported, or used for disposal? (For example, it appears that DOE may still need to develop designs for handling the MCO and complete operational safety analyses before it could be incorporated into the Yucca Mountain repository design. (slides 15 thru 22, and MCO presentation)

NWTRB Questions

5. Could each type of multi-purpose canister be used for disposal in the other rock types and what work has been done on analyzing this question? (See Bonano presentation at Board workshop as an example of assessing disposal options.) (slides 23 and 24)
6. Has each type of container been certified by NRC for transportation or are there plans to certify the containers for transport, if so when? (slides 15 thru 18)
7. How many of each type of container are used for storage? (slides 19 and 20)
8. What, if any, DOE SNF will not be loaded into standardized/multi-purpose canisters, and how would that material be transported to a repository? (slide 20)