Waste Package Design and Prototyping

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Outline

- Waste package design requirements
- Description and major features of waste packages
- Waste package design code
- Prototyping programs
  - Waste package and components
  - Closure system
Waste Package Design Requirements

- **Preclosure**—Important to safety and must:
  - Facilitate safe and efficient loading of canistered spent nuclear fuel (SNF) and high-level radioactive waste (HLW)
  - Be transportable within surface facilities and to emplacement drifts
  - Be safely and efficiently sealed remotely
  - Be retrievable
  - Meet preclosure safety requirements
    - Ensure breach is beyond Category 2 for design basis event sequences
    - Preclude criticality

- **Postclosure**—Important to barrier capability and must meet long-term dose performance requirements
Features of Waste Packages

- Alloy 22 outer corrosion barrier is long-term corrosion-resistant barrier
- Alloy 22 sleeves provide stiffness and contact points
- SS-316 inner vessel supports the structural performance of the outer corrosion barrier
Recent Changes to Waste Package Design

- **Removal of internals from commercial SNF-bearing configurations**
  - Increased cavity volume
  - Accommodates transportation, aging, and disposal (TAD) canisters
  - Changed suite of configurations (10 to 6)
  - Criticality control now included in TADs

- **Deletion of inner Alloy 22 lid**

- **Addition of a shield plug for Department of Energy (DOE) SNF and HLW-bearing waste packages**

- **Removal of receiver grooves for trunnion collars**
  - Reflects changes in handling approach in the surface facilities
Suite of Waste Package Configurations

21-PWR/44-BWR TAD

2-MCO/2-DHLW Long

5-DHLW/DOE SNF Short

5-DHLW/DOE SNF Long

Naval SNF Short

Naval SNF Long
Criticality Control Imposed on Canisters

- DOE SNF standardized canisters
  - Neutron poisons tailored to waste forms

- TAD canister
  - Either
    - Include neutron absorber plates, tubes, or both, made of powder metallurgy borated stainless steel
    - Implement the postclosure criticality methodology for specifically defined configurations
  - Details provided in TAD canister performance specification
TAD/Naval Waste Package

- Closure Weld
- Seal Welds (Fillet)
- Spread Ring (0.88 in)
- Alloy 22 OCB Lid (1 in)
- Alloy 22 OCB (1 in)
- Inner Vessel (2 in)
- Inner Vessel Lid (2 in)
DOE Waste Package

- Closure Weld
- Seal Welds (Fillet)
- Spread Ring (0.88 in)
- Alloy 22 OCB Lid (1 in)
- Alloy 22 OCB (1 in)
- Inner Vessel (2 in)
- Inner Vessel Lid with Integrated Shield Plug (8 or 9 in)
Waste Package Codes and Standards

- Inner vessel is fabricated to the ASME Code, Section III, Division 1; Subsection NC (Class 2 Pressure Vessel) and has the N Code Symbol Stamp Affixed
- Outer corrosion barrier is constructed to the specific provisions of the ASME Code Section III, Division 1; Subsection NC (Class 2 Pressure Vessel)
- Materials are specified to the ASME Code, Section II, Materials Definitions
- Nondestructive examinations (NDEs) are performed to ASME Code, Section V, Nondestructive Examination
- Welding is performed to ASME Code, Section IX
Waste Package and Components Prototyping Program Objectives

- Develop and confirm fabrication methods
- Inform definitive design of design alternatives
- Demonstrate commercial vendor capability
- Develop a cadre of qualified vendors
- Estimate future costs and fabrication duration
- Evaluate manufacturing process variability
- Support start-up testing and provide training exhibits
Inform Definitive Design

- Provide information on achievable tolerances
- Provide samples for destructive testing to ensure that long-term performance characteristics are achieved
- Ensure that handling techniques are achievable in practice
Support Factory Acceptance and Start-Up Testing

- Receipt inspection
- Handling of waste package before loading with waste form
- Placement onto and maneuvering on emplacement pallet
- Waste form loading
- Handling after waste package closure
- Emplacement activities
- Handling equipment factory acceptance testing (FAT)
First Prototype

- 21-PWR absorber plate waste package configuration
- Finished in January of this year
- Presently stored at fabricator awaiting initiation of testing program
Testing Program for First Prototype

- **Residual stress measurements**
  - Stress fields due to outer corrosion barrier solution heat treating
  - Dimensional consistency and induced stresses due to shipping and storage at rest

- **Mechanical testing**
  - Mechanical and corrosion properties
    - Includes preparation of an “atlas” of marring and other physical damage and determination of changes to residual stress distributions
  - Metallographic examinations
  - Samples for subsequent corrosion testing

Thermal testing for fit-up

Predecisional—Preliminary
Lessons Learned from First Prototype

• **Welding**
  – The automatic tungsten arc process with camera controls worked well with no defects
  – A fillet weld was required on the inside of the lower lid weld to comply with the ASME Code; this has been added to the design documents

• **Machining**
  – Machining Alloy 22 challenges are not widely understood
  – Additional information on the feed rate and machine speed required to successfully machine will be provided in the specification
  – Small machine shops do not have the capability to machine the inside diameter of the vessels because of the "reach" necessary (approximately 16 feet)
Lessons Learned from First Prototype

• Annealing process
  – Extra fabrication stock has been added to the outer cylinder to facilitate machining the inner diameter after annealing
  – The sleeves on the outer vessel should be annealed separately prior to installation to ensure dimensional stability and to reduce the distortion during annealing
  – When annealing with the closed end up, the vessel requires snorkels to remove the trapped steam in addition to water spray to remove steam pockets
## Follow-on Waste Package Prototypes

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<thead>
<tr>
<th>No.</th>
<th>Configuration</th>
<th>Status</th>
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<tr>
<td>1</td>
<td>21-PWR Absorber Plate</td>
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<tr>
<td>2</td>
<td>TAD-bearing [1]</td>
<td>Entering Procurement</td>
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<tr>
<td>3</td>
<td>TAD-bearing [1]</td>
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<td>4</td>
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</tr>
<tr>
<td>5</td>
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</tr>
<tr>
<td>6</td>
<td>HLW-bearing [2]</td>
<td>Planned</td>
</tr>
</tbody>
</table>

[1] The current TAD-bearing waste package is identical to the Naval Long Waste Package.

[2] The identities of these configurations are contingent on experience with prior prototypes.
Drip Shield and Pallet Prototypes

- Fabricate two pallet prototypes (long and short)
  - Support FAT testing for transport and emplacement vehicle (TEV) as well as surface handling equipment
  - Support start-up testing for waste package handling

- Fabricate two drip shield prototypes
  - Confirm the connection/interlock feature
  - Support FAT testing for drip shield gantry
  - Support start-up testing for drip shield emplacement
Mock-ups for Closure Weld System Development

- Closure weld and NDE systems being developed at Idaho National Laboratory
- “Short” closure end, full-diameter, mock-ups being fabricated for development and testing of these systems
- Fabrication of first mock-up scheduled to be complete in midsummer 2008
- Demonstration of waste package closure system scheduled for October 2008
Waste Package Closure Cell Prototyping
Program Objectives

- Simulate entire waste package closure system
- Confirm welding techniques
- Confirm effectiveness of NDE methods
- Confirm inverting and leak testing of the welds
- Develop process operations in repository facilities
- Support start-up testing and provide training exhibits
Closure Cell Welding Equipment

Welding End Effector

Robotic Arm
Closure Cell NDE Equipment

- Visual inspection performed by cameras located on welding end effector
- Eddy current and ultrasonic end effector
- Attached to robotic arm
Closure Cell Inerting and Leak testing

- Ability to inert the waste package internals through purge port plug
- Leak test the inner lid closure welds
Summary

- Waste package design requirements adapted for implementation of TADs
- Criticality control requirements a canister function
- Prototyping program
  - First prototype complete
  - Testing to confirm consistency with postclosure analysis planned
  - Future prototypes planned
  - Closure cell prototyping