U.S. Department of Energy
Office of Civilian Radioactive Waste Management

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Waste Package Design and Prototyping

Presented to:
NWTRB Spring Board Meeting

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Predecisional—Preliminary

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**

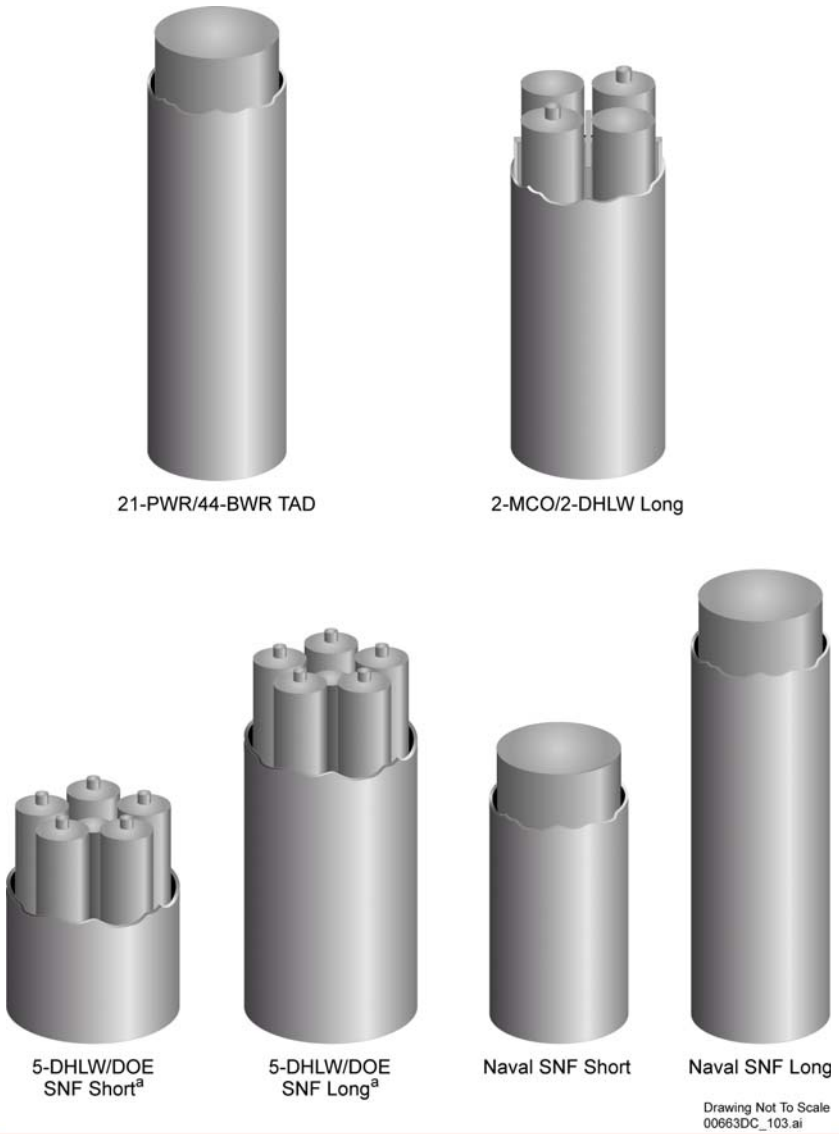
Features of Waste Packages

- **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**

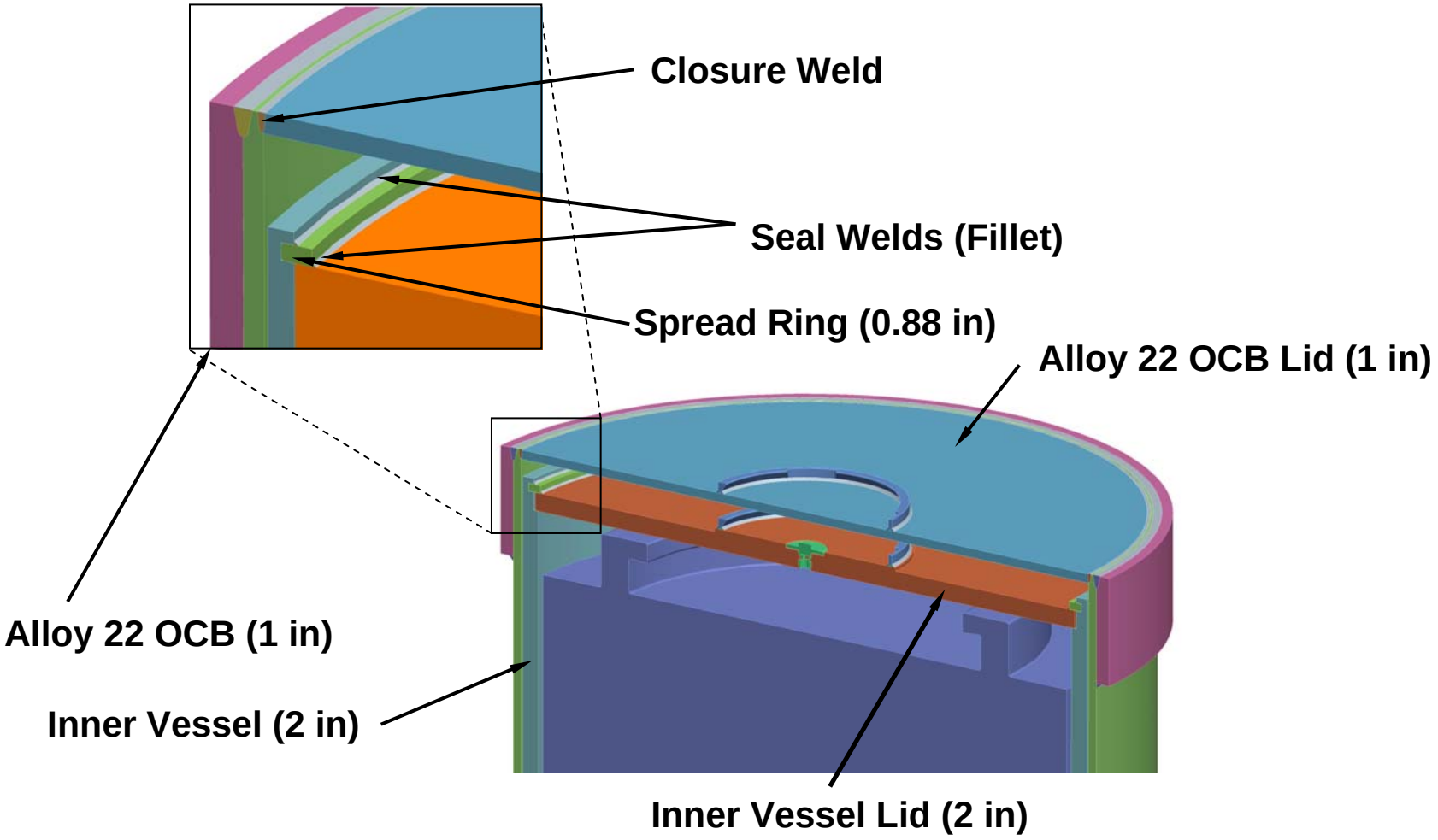
Suite of Waste Package Configurations



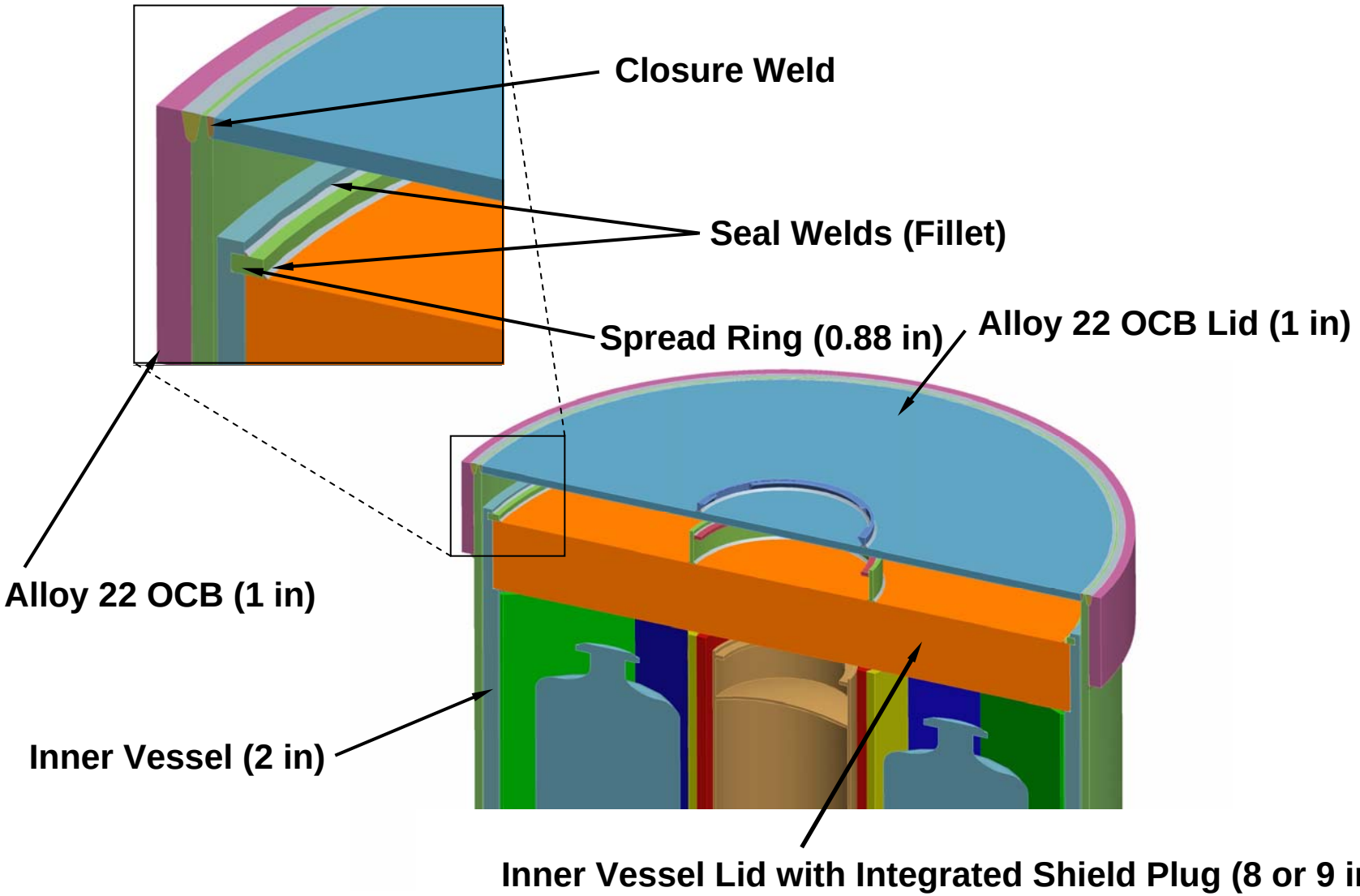
Criticality Control Imposed on Canisters

- **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



DOE Waste Package



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

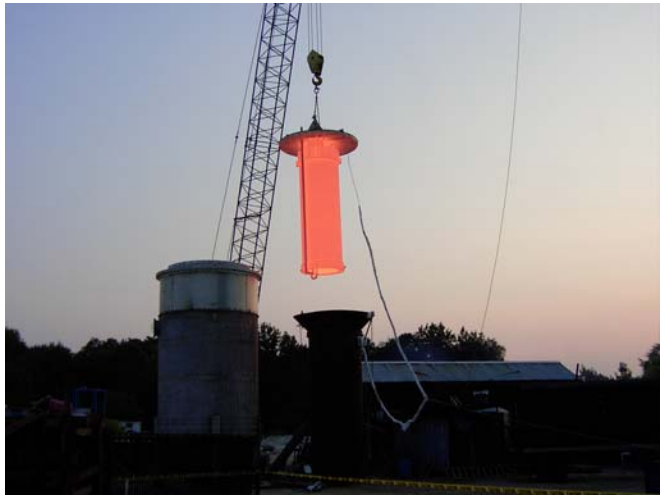
- **Provide information on achievable tolerances**
- **Provide samples for destructive testing to ensure that long-term performance characteristics are achieved**
- **Ensure that handling techniques are achievable in practice**

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

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 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

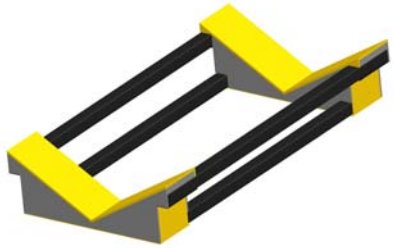
No.	Configuration	Status
1	21-PWR Absorber Plate	Complete
2	TAD-bearing [1]	Entering Procurement
3	TAD-bearing [1]	Planned
4	TAD-bearing [1]	Planned
5	HLW-bearing [2]	Planned
6	HLW-bearing [2]	Planned

[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**

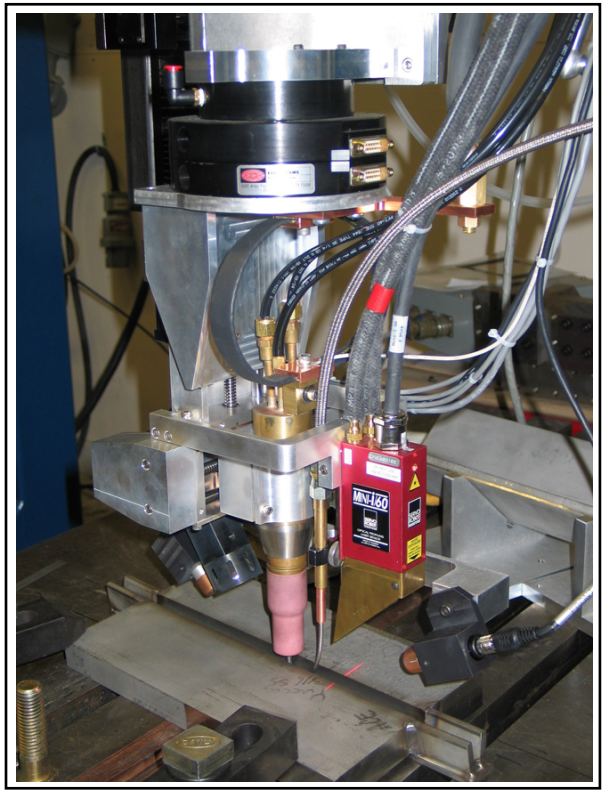
Mock-ups for Closure Weld System Development

- 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 inerting 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 Effecter

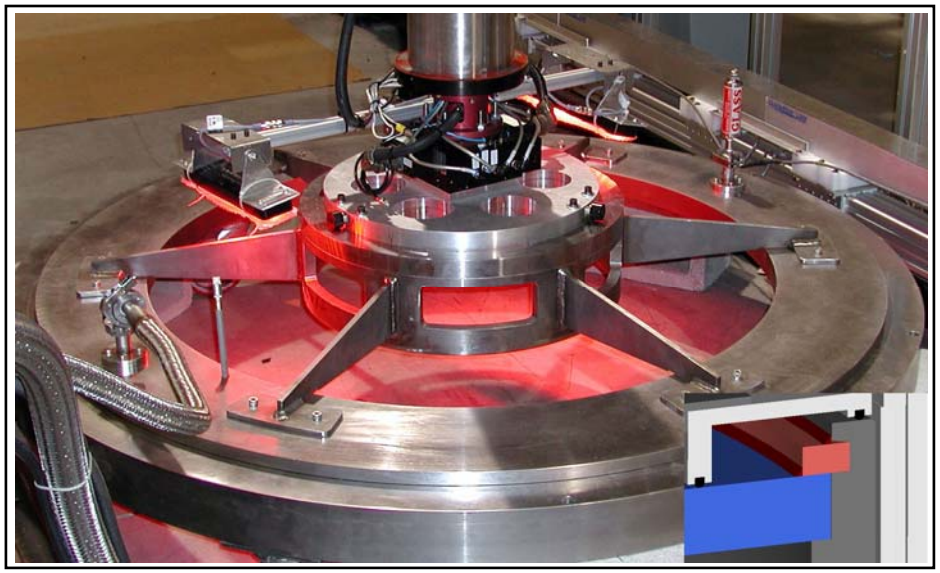
Robotic Arm

Closure Cell NDE Equipment

- Visual inspection performed by cameras located on welding end effecter
- Eddy current and ultrasonic end effecter
- 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**