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OPTIONS FOR USING THE DOE STANDARD CANISTER TO SUPPORT THE DOE-NE PROGRAM

Josh Jarrell, Ph.D.
Manager, Used Fuel Management Department
Idaho National Laboratory

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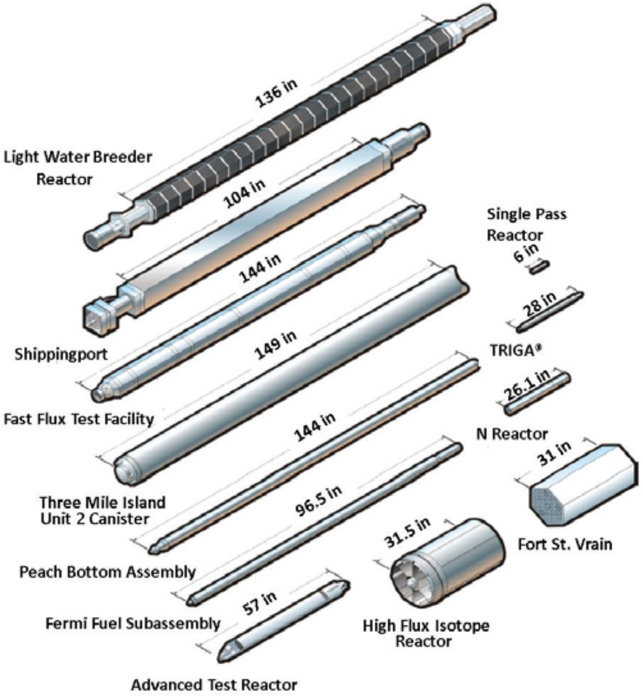
Overview of Presentation

- Background on DOE-managed fuel and DOE Standard Canister
- Overview of current DOE-NE-funded activities
  - DOE's efforts to develop the DOE Standard Canister
  - Evaluation of neutron absorbers for the DOE Standard Canister
  - Evaluation of loading DOE Standard Canisters at the CPP-603 facility
  - DOE Standard Canister demonstration project: status and path forward
- Conclusions

DOE manages a broad range of spent fuels

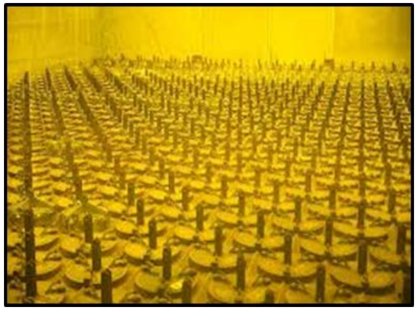
- Different types and forms of spent nuclear fuel (SNF)
  - Low-enriched uranium to highly-enriched uranium
  - Different clads (aluminum, zirconium, stainless steel etc.) and fuel material (metal, oxide, carbide, etc.)
  - Range of geometries and sizes
- Different current configurations



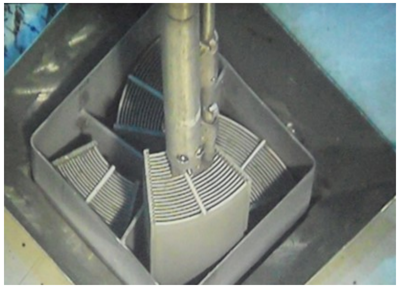
Some examples of SNF types

Wet storage, CPP-666, at the INL site

Below-grade storage facility CPP-749 at the INL site



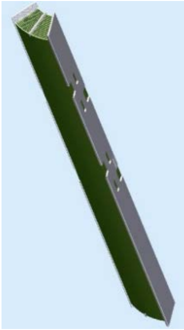
Dry storage system, CPP-603, at the INL site



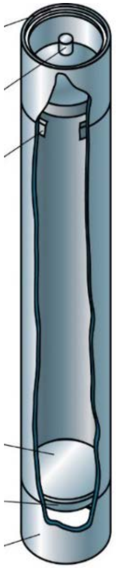
Advanced Test Reactor (ATR) fuel elements

DOE has designed the DOE Standard Canister to manage this material/fuel using a standard, consistent approach

- To support storage, transportation, and disposal of a broad spectrum of fuels, DOE began investigating the DOE Standard Canister in the early 1990s
  - Goal was **to minimize reliance on the fuel forms** and characterization and instead rely on canister performance
  - Referenced in the Idaho Foster Wheeler storage facility (licensed by the Nuclear Regulatory Commission (NRC)) and the Yucca Mountain license application
  - Designed to accommodate most of the non-commercial SNF besides the N reactor SNF currently stored in multi-canister overpacks at Hanford



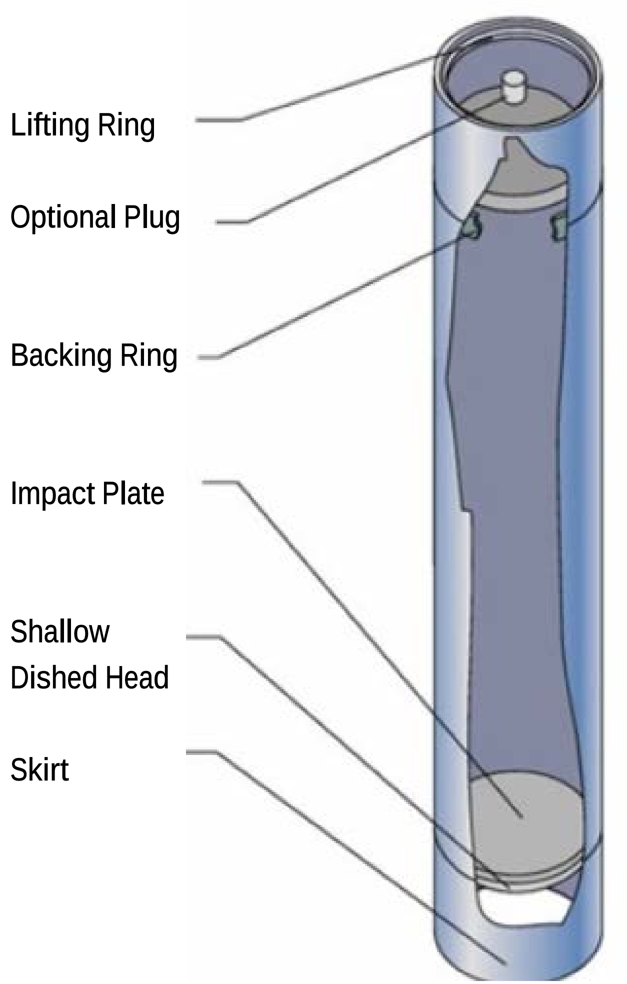
SNF into Standard Canister



Standard Canister into Storage Cask

Standard Canister into Transportation Cask

The DOE Standard Canister



<u>Nominal Outside Diameters:</u>
18 in. and 24 in.

<u>Wall Thicknesses:</u>
3/8 in. for 18 in. canister
1/2 in. for 24 in. canister

<u>Maximum Weight with Fuel:</u>
5,000 to 10,000 lbs.

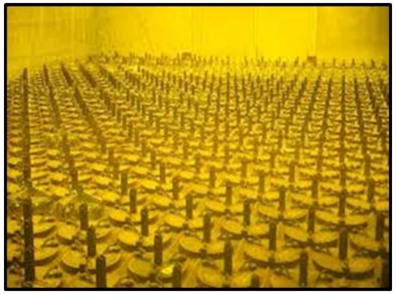
<u>External Lengths:</u>
Short Canister: 118.11 in.
Long Canister: 179.92 in.

<u>Material</u>
Canister Body: SS316L

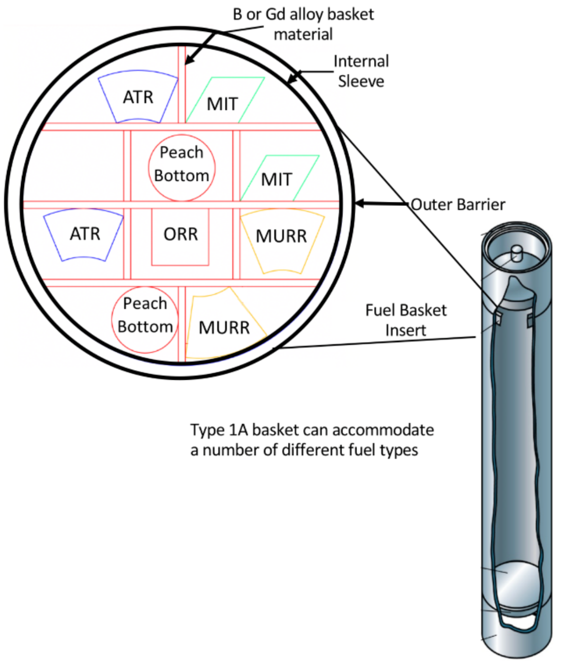
The Standard Canister is a near-term option that achieves road-ready dry storage for Advanced Test Reactor (ATR) spent fuel

- ATR generates approximately 100 spent fuel elements each year
- Current planning includes moving this fuel from ATR to the dry storage facility at the CPP-603 dry storage facility
  - However, CPP-603 is currently being re-configured to increase capacity
- There are limited viable alternatives if CPP-603 became unavailable (i.e., reaching capacity)
- The Standard Canister would provide a near-term storage **option** for ATR SNF
  - With the goal to be road-ready and disposal-ready

ATR element

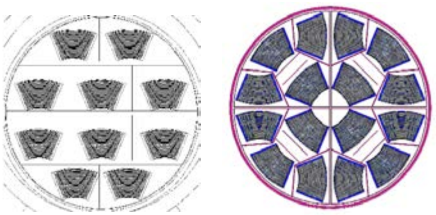


Dry storage system, CPP-603, at the INL site

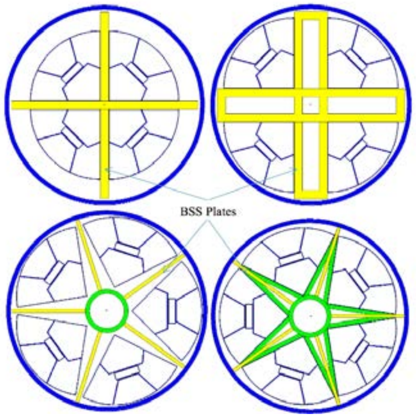


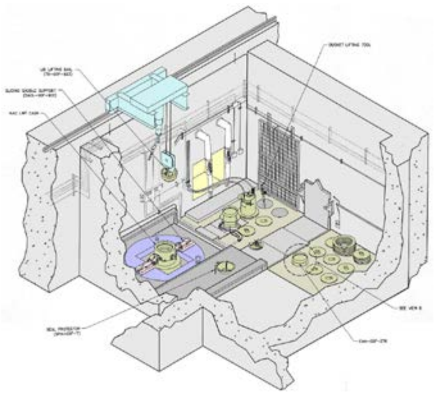
Current evaluation efforts are focused on four main areas

- Canister system design including disposal scenarios
  - Criticality control is being evaluated
  - Different poisons for neutron absorption (borated stainless steel vs Ni-Cr-Mo-Gd alloy)
  - Different poison locations
- Operational and facility evaluation
  - Facility layout and operations are being evaluated (e.g., inerting, welding, remote non-destructive examination, decontamination)
- Storage configuration options
- Transportation certification and options (not yet initiated)
  - Make system “road-ready”



Canister configuration options





CPP-603 Fuel Handling Cave

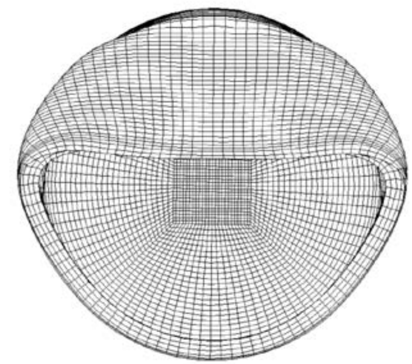
Proposed packaging facility

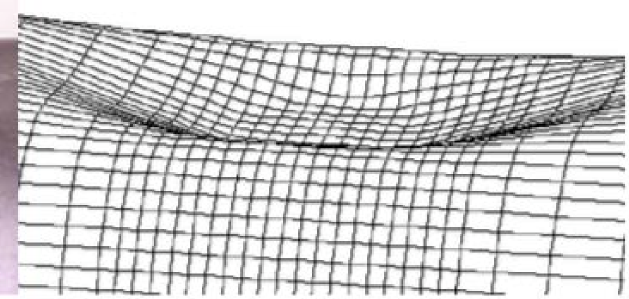
Brief History of the DOE Standard Canister

- National Spent Nuclear Fuel Program established to develop a timely, cost-effective technical solution for DOE SNF management (1995)
- Proposed co-disposal waste package concept places a DOE Standard Canister and 5 high-level waste (HLW) canisters in a disposal package (1995)
- Began working on alternative neutron absorbers (1999)
- Completed drop tests, heights per 10 CFR 71.73(c), with prototype canisters (1999)
- NRC approves Foster Wheeler storage application (NRC license #SNM Docket No. 72-25) to construct and operate a spent fuel storage facility (2001)
- Initiated series of meetings with NRC to confirm canisters could obtain credit for moderator exclusion during transport (2006)
- Canister concept submitted with License Application for Yucca Mountain (2008)
- Funding for DOE Standard Canister was reduced and eventually suspended (2008)

History of the DOE Standard Canister: Technical Evaluations

- A number of evaluations were performed to understand the performance of the Standard Canister and no “show-stoppers” were found
  - Canister finite element analyses
  - Canister drop tests
  - Materials interaction
  - Neutron absorber selection
  - Closure welding
  - Radiological source term estimates
  - Radiological dose consequence analysis
  - Post- and pre-closure criticality analysis





Neutron Absorber Evaluation: Purpose

- The basket of the DOE Standard Canister was the preferred location of neutron absorber
  - The selected approach for Yucca Mountain was to **reduce the probability of criticality** for the relevant period of performance per 10 CFR Part 63
- A new neutron absorber material was proposed for use in DOE Standard Canister: Advanced Neutron Absorber (ANA) made of Ni, Cr, Mo, and Gd
  - Gadolinium was determined to be less soluble than boron
  - Initial corrosion tests showed poor corrosion performance for borated stainless steels
- Later, other fabrication techniques for borated stainless steel (304B4, 304B5) showed better corrosion performance (in specific environments)
  - The Transportation, Aging, and Disposal (TAD) canister for commercial SNF proposed to use borated stainless steel.

Transportation, Aging, and Disposal Canister for Commercial SNF

Neutron Absorber Evaluation: Past Results and Limitations

- A study sponsored by the NRC in 2011 determined the maximum corrosion rates of 304B4 and 304B5 in water and humid air.
- Another study compared the corrosion rates of BSS and ANA in 2011.
  - Determined 304B4 was less corrosive than ANA in limited testing environments.
- Borated Stainless Steel (BSS)
  - Currently commercially available
  - Corrosion resistance decreases as concentration of boron increases
- Advanced Neutron Absorber (ANA) with Gadolinium
  - Less soluble than boron

	304B4 (1.04%B)	304B5 (1.34%B)
Maximum Corrosion Rate	80nm/yr	600nm/yr
Thickness Degraded After 10,000	0.16 cm	1.2 cm

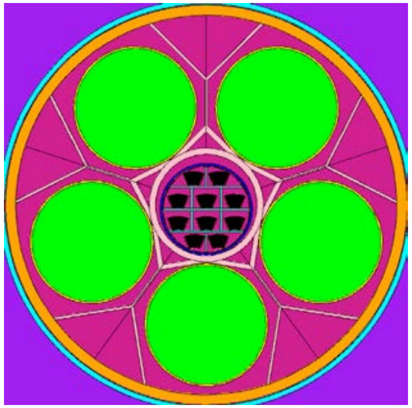
He. X., Ahn, T., Sippel, T. *Corrosion of Borated Stainless Steel in Water and Humid Air*, Contract NRC-02-07-006, September 2011.

	304B4 (1.17%B)	ANA (1.89%Gd)
Potentiostatic Corrosion Rate	32.5 nm/yr	16,300 nm/yr
Linear Polarization Resistance	221 nm/yr	24,100 nm/yr

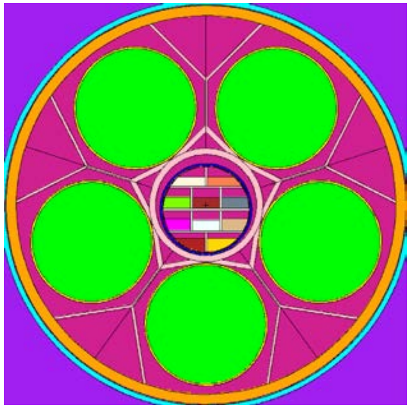
Mizia, R., Lister, T. *Accelerated Testing of Neutron-Absorbing Alloys for Nuclear Criticality Control*, Nuclear Technology, 176:1, 9-21, DOI: 10.13182/NT11- A12539, 2011.

Alternative Neutron Absorber Results for ATR Elements

- Analyzed 65 distinct cases including broad range of intact and degraded configurations
  - Most limiting cases included degraded fuel with intact HLW canisters (i.e., disposal scenarios)
- A borated stainless-steel basket has a lower k_{eff} than an ANA basket in every case.

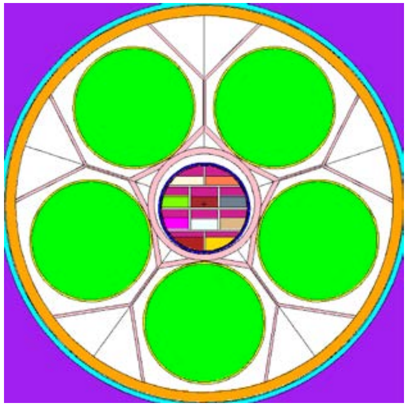


(1) Intact co-disposal waste package with intact ATR fuel in an intact DOE Standard Canister surrounded by intact HLW canisters, Flooded



(2) Intact co-disposal waste package with **degraded** ATR fuel in an intact DOE Standard Canister surrounded by intact HLW canisters, Flooded

Description	ANA k_{eff} (+2σ)	304B4 1.17% B k_{eff} (+2σ)	304B4 1.00% B k_{eff} (+2σ)
1. Intact, horizontal co-disposal package with 5 HLW and 1 18" flooded SNF canister with intact ATR elements with flooded WP	0.626	0.590	0.598
2. Same as (1), but with flooded, degraded ATR elements with flooded WP	0.808	0.770	0.776
3. Same as (1), but with flooded, degraded ATR elements with Dry WP	0.826	0.789	0.797

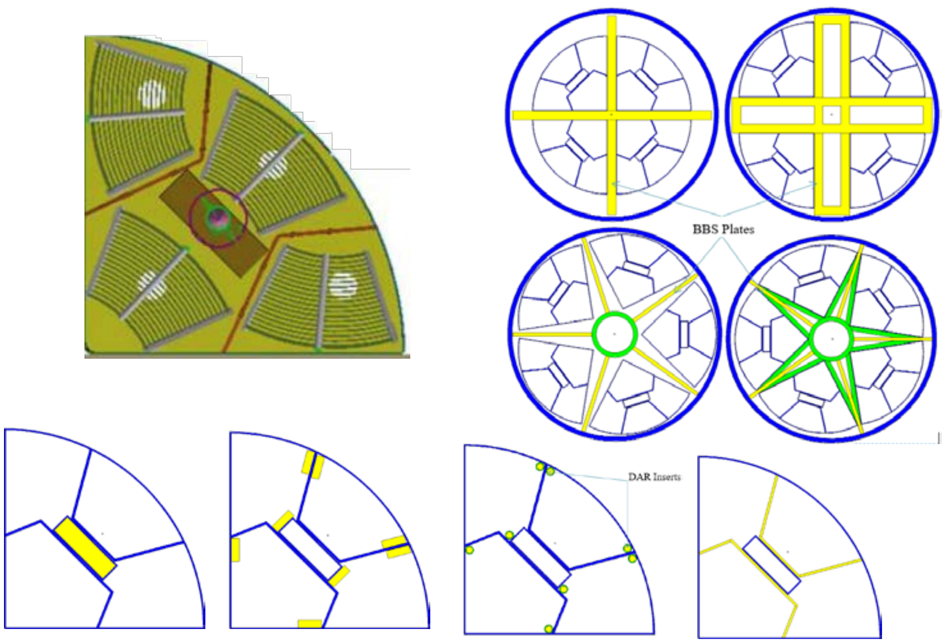


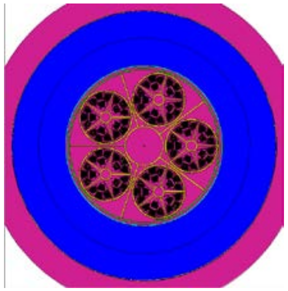
(3) Intact co-disposal waste package with **degraded** ATR fuel in an intact DOE Standard Canister surrounded by intact HLW canisters, Dry

Alternative ATR-specific DOE Standard Canister Geometries

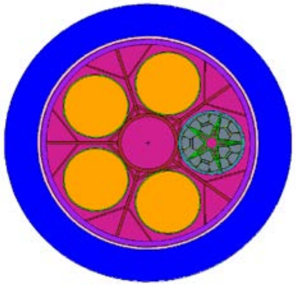
- Some ATR elements are stored in ATR4 buckets at the INL site dry storage (CPP-603)
- Throughput could be increased and number of canisters may be reduced with alternative packaging options
- Criticality evaluations were performed with alternative geometries
  - Intact and degraded scenarios
  - Poison plates, bars, and inserts considered
- With additional neutrons poison inserts, even most reactive disposal scenario has a k-effective less than 0.93

Description	k_eff (+2σ)
Storage configuration – fully flooded, no absorbers	0.829
Disposal configuration – fully degraded, no absorber	1.068
Disposal configuration – fully degraded, BSS plates between buckets, BSS inserts and BSS bar in the ATR4 buckets	0.927





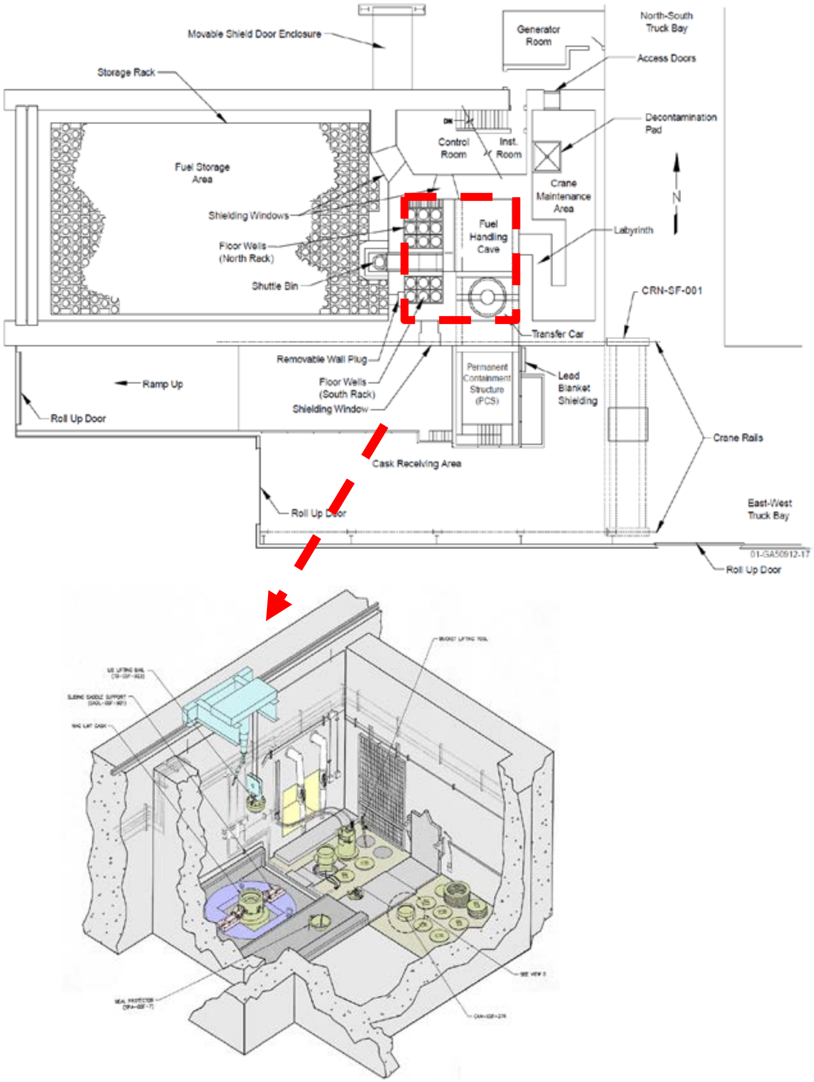
Storage configuration: Intact ATR Fuel in 2 levels of 5 ATR4 Buckets in each of 5 24"-OD DOE Standard Canisters in a MPC in a thick concrete Storage Overpack



Disposal configuration: Degraded ATR Fuel (gibbsite and schoepite) from 2 levels of 5 ATR4 buckets in a 24"-OD DOE Standard Canister in a Co-disposal Waste Package with 4 DHLW glass canisters

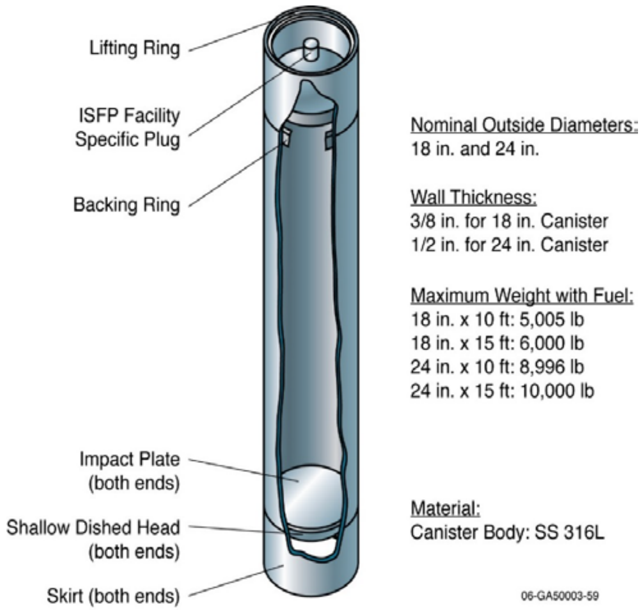
Evaluation of Loading Operations at Current INL facilities: CPP-603

- Detailed 3D mapping of facility
  - Goal is to understand tolerances and clearances to support future closure operations
- Begin developing operational/procedural concepts for standard and new operations for Peach Bottom and ATR fuels
  - Drying
  - Welding and associated weld confirmation (non-destructive examination) and repair
  - Inerting/backfilling
  - Decontamination
  - Material movement
- No technical showstoppers for loading DOE owned SNF at CPP-603
  - Technology development and deployment will be required



Conclusions

- The DOE Standard Canister could provide a near-term storage option for DOE managed fuels
  - Designed with road-readiness and disposal in mind
  - Referenced in past disposal and storage licensing applications
  - Designed to withstand transportation hypothetical accident drops without additional overpacking (i.e., a VERY robust package)
- Basket designs are being analyzed to provide enhanced confidence in sub-criticality during disposal
- The CPP-603 facility appears suitable for canister loading operations



Questions?

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