U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

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Hanford Lead Canister Overview and Status

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UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
Winter 2022 Board Meeting
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Virtual Meeting

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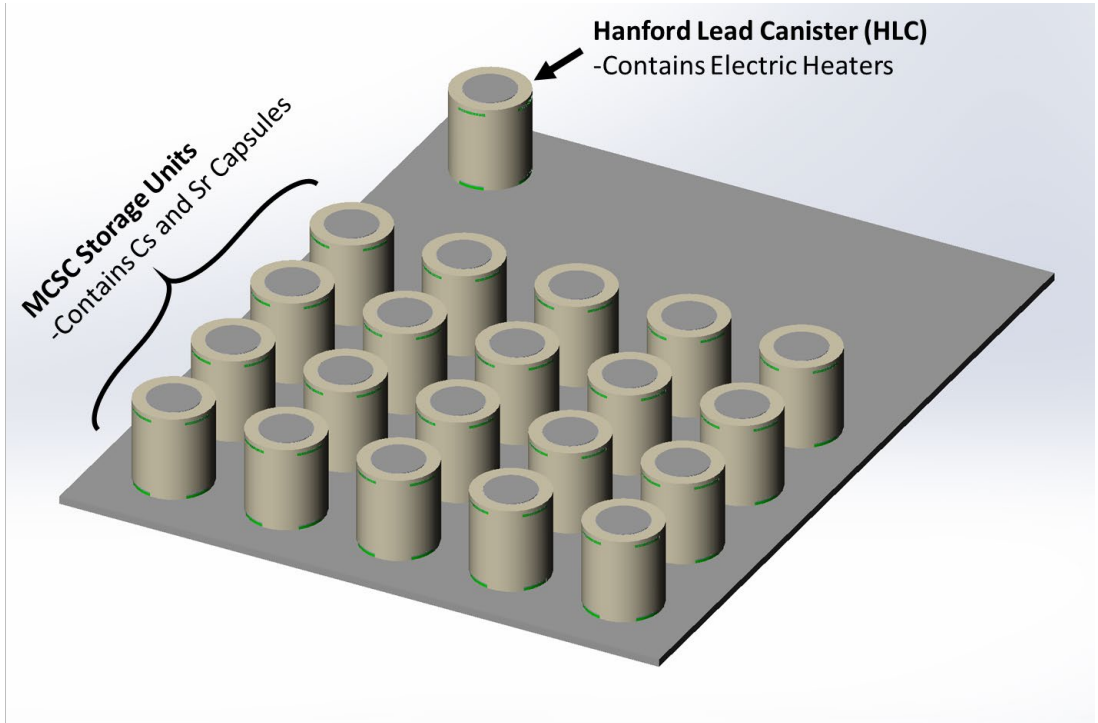
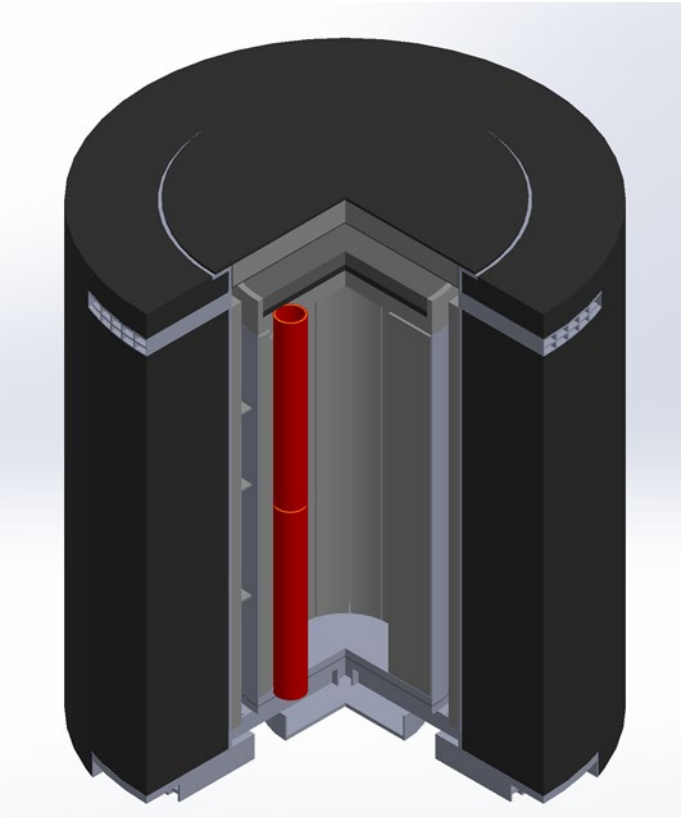
Hanford Lead Canister (HLC) Project

This project is developing a leading indicator canister for the Hanford site's cesium and strontium dry storage facility. The HLC will provide advance warning for signs of Chloride Induced Stress Corrosion Cracking (CISCC).





MCSC: Management of Cesium and Strontium Capsule Project

HLC Collaboration

A key feature of the HLC project is broad collaboration.

DOE-NE	Industry	DOE-EM
NE-81	NAC Int.	DOE-RL
NE-82	EPRI	Hanford Site
	ASME BPVC	CPCco

HLC Timeline

This project has a long timeline that offers many different opportunities for collaborative research and development related to canister aging management.

Outline

- **Hanford Lead Canister (HLC) Background**
  - Presented by Gary Cannell, Fluor/CPCco
- **Connections to Important Technical Topics**
- **Project Status**
- **Closing Remarks**

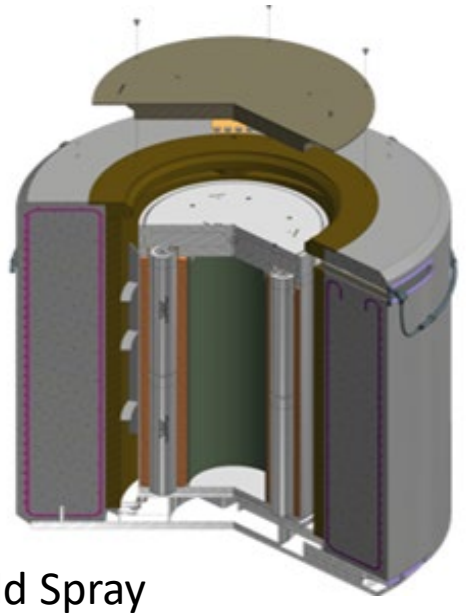
HLC Background

Hanford Cs/Sr Capsules – Wet Pool to Dry Storage

- Hanford developing capability to transfer nearly 2,000 Cs/Sr Capsules from wet pool to dry storage
- Capsules to be packaged into standard dry cask storage systems and placed on a concrete pad
  - Systems are similar to current SNF dry storage systems
- Design storage term – up to 300 years

Capsule Dry Storage System

- Capsule system design and fabrication are unique within the dry storage community
  - System design and fabrication specifically considered aging management
  - Design features
    - Corrosion resistant materials – Stainless Steel Type 316L vs. 304L
    - Expanded annulus (canister OD – cask liner ID) for in-service inspection (ISI)
    - Alignment of air vents with canister longitudinal weld seams – facilitate ISI
  - Fabrication features
    - Minimization of weld heat input
    - Limits on number and type of weld repairs
    - Minimization of grinding and other material stress-inducing practices
    - Isolation of canister weldment heat affected zones from the environment – Cold Spray



- Key to aging management – Use of a Lead Canister

Hanford Lead Canister

- Full production quality capsule dry storage system – multi-function
- Primary function – Leading Indicator for Cs/Sr cask inventory
  - Configured to represent most susceptible canister in inventory
  - Will be used for inservice inspection – no dose and ready access
- Secondary functions:
  - Mockup for inservice and mitigation & repair (M&R) activities
    - Training, procedures, practice, etc.
    - Demonstrate, in-situ, developed inspection and M&R technologies
  - Mockup for M&R technology development / demonstration
    - Several potential technologies identified – Surface Stress Improvement (e.g., Laser Peening), solid-state processes, polymeric . . .
      - None of which have been demonstrated in a field condition
  - Field service data collection

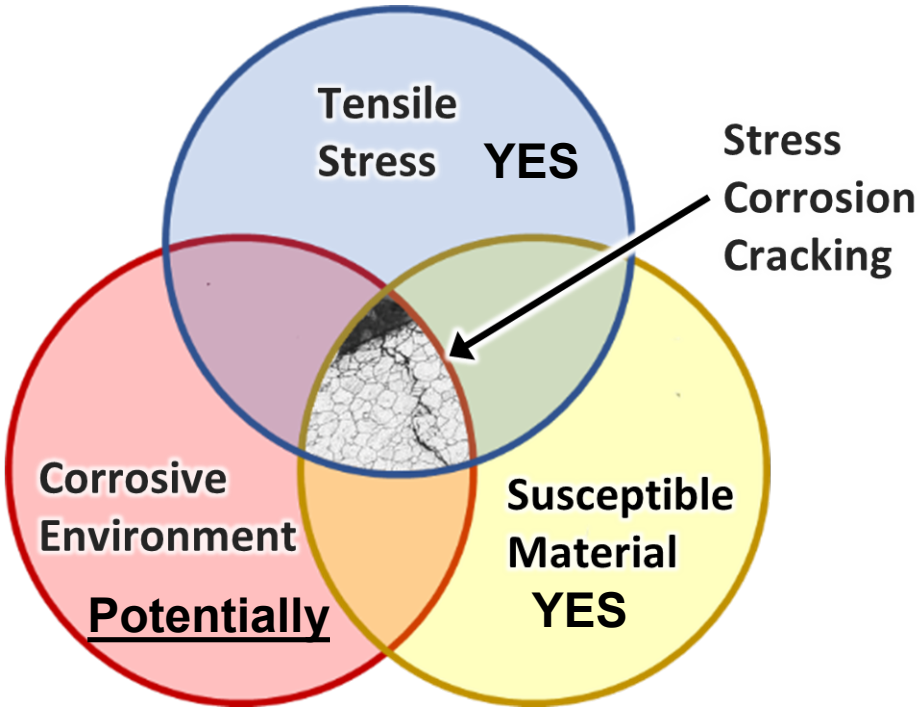
Hanford Lead Canister

- Significant interest and activity surrounding dry storage canister M&R
  - Multiple DOE, EPRI and Industry programs developing M&R technologies
  - ASME currently developing code case for M&R rules
- DOE making the Lead Canister available to the dry storage community for:
  - Technology development and demonstration
- Lead Canister leadership team preparing for these activities:
  - Hanford: Facility operations and maintenance
  - PNNL:
    - Technology development / demonstration
    - Interface with the dry storage community
  - EPRI: Technology development / demonstration

Connections

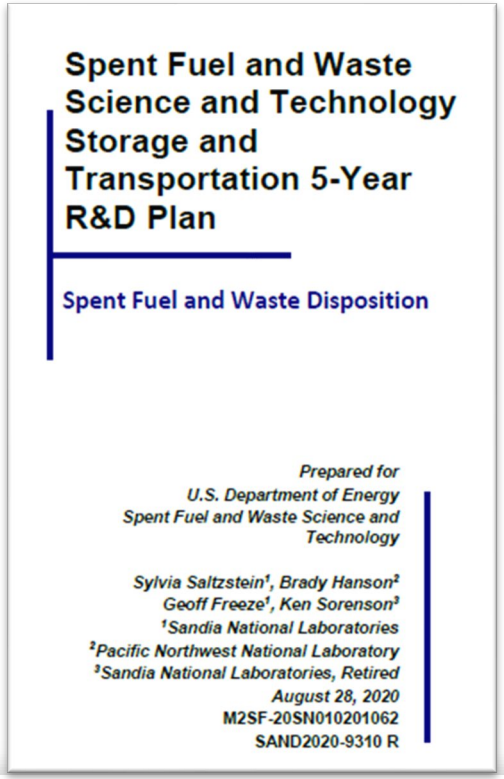
Connection: CISCC in SNF Canisters

CISCC: Chloride Induced Stress Corrosion Cracking



One big outstanding technical question surrounding CISCC in SNF canisters is: What is the environment an SNF canister witnesses within a dry storage system?

Spent Fuel and Waste Science and Technology Program
2020 Priority Level 1:
Welded Canister – Atmospheric Corrosion


Spent Fuel and Waste Science and Technology Storage and Transportation 5-Year R&D Plan

Spent Fuel and Waste Disposition

Prepared for
U.S. Department of Energy
Spent Fuel and Waste Science and Technology

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[1]Sandia National Laboratories
[2]Pacific Northwest National Laboratory
[3]Sandia National Laboratories, Retired
August 28, 2020
M2SF-20SN010201062
SAND2020-9310 R

Connection: Environment, Material Deposition, Presence of Chlorides

- HLC offers easy access to canister surface for sampling dust and identifying the chemicals that are present on the canister surface over time.
- Provides data for validating deposition models.
- Offers insight into the inland dry storage environment.

https://www.freeworldmaps.net/united-states/washington/map.html

Connection: Mitigation and Repair of Stainless Steel Canisters

- **Hanford canisters are the first to incorporate cold spray at fabrication.**
- **HLC provides an opportunity to demonstrate mitigation and repair technologies.**
  - EPRI coupon panel R&D.
  - PNNL coupon panel R&D.
  - Other opportunities TBD.

POC: Jon Tatman (EPRI)
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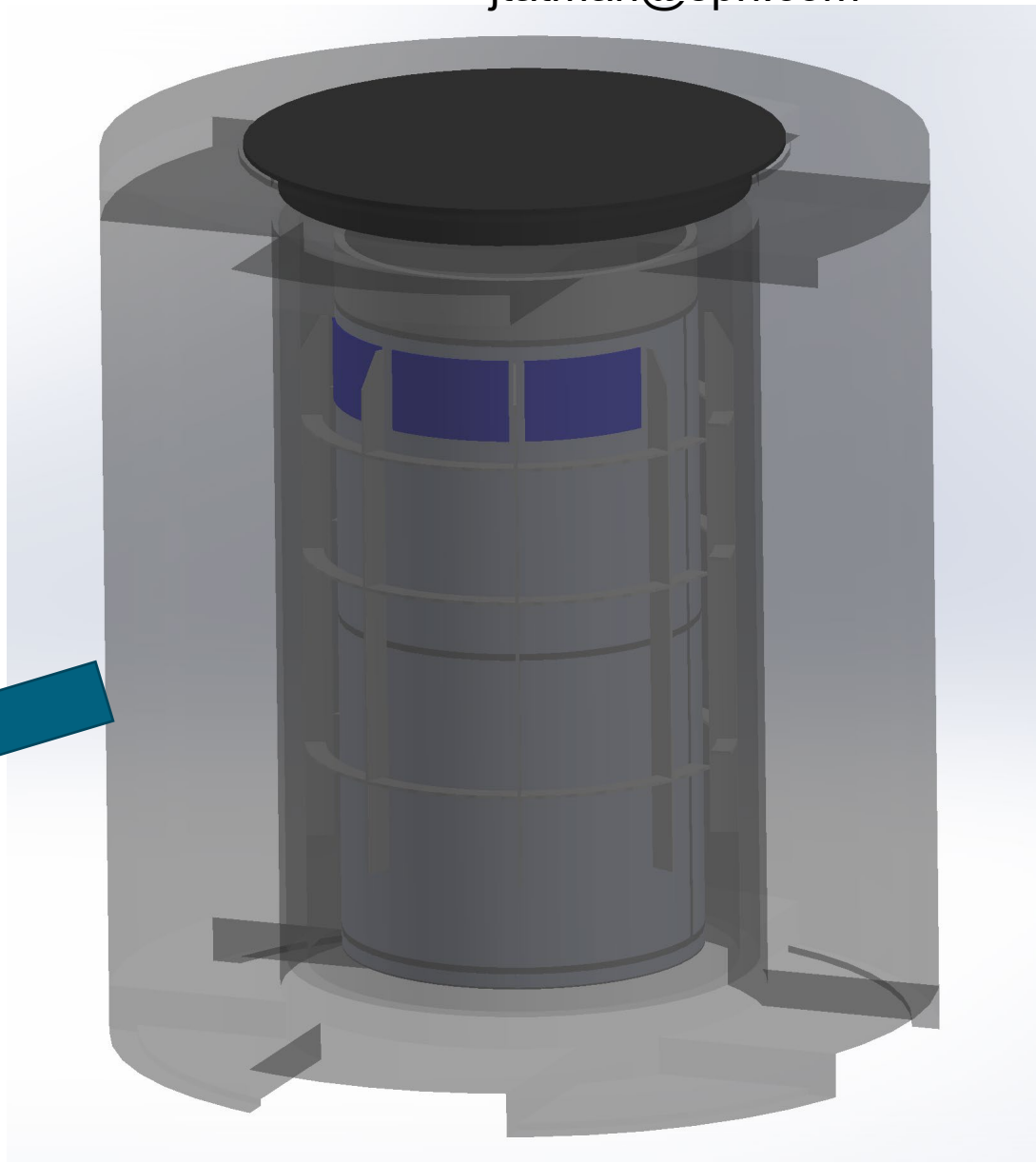
EPRI Coupon Panels

- EPRI test will be in 2022-2023 time frame
- Bolt coupon panels to Transportable Storage Canister (TSC)
- EPRI to demonstrate *in situ* repair and mitigation
- Heaters on for accurate environment
- Performed at truck port mockup



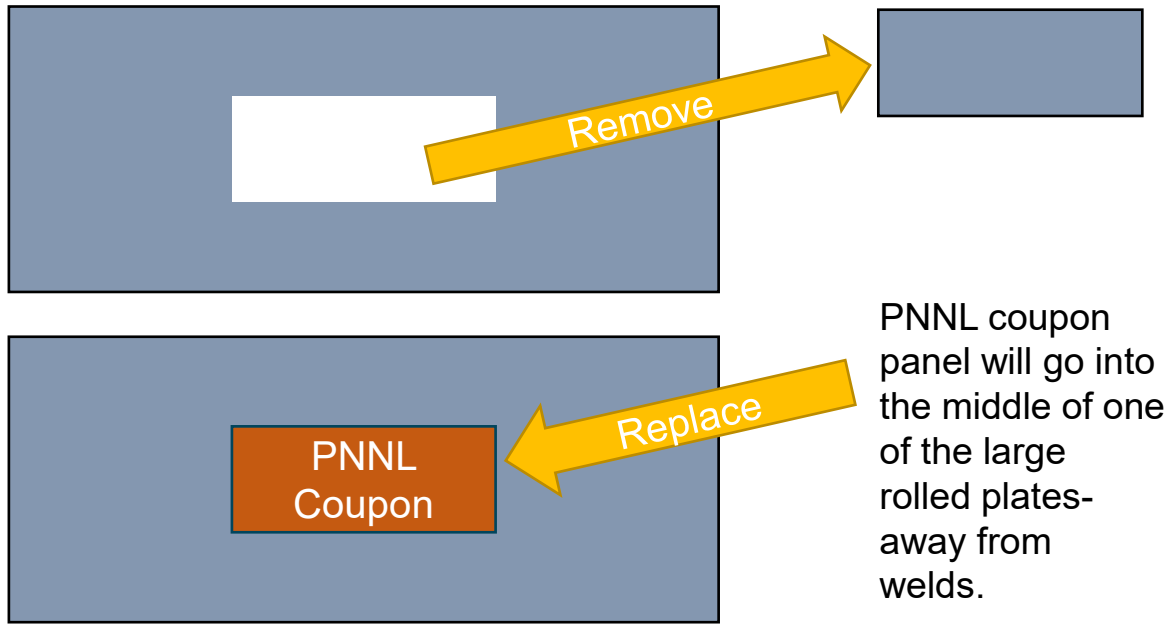
Technical Challenges:

- Practical demonstration of technology.

PNNL Coupon Panel Concept

TSC Welds
- 2 circumferential welds
  - Lid
  - Baseplate
- 1 or 2 Vertical seam welds
  - 0-degrees
  - 180-degrees (optional)
- Note: Welds are cold-sprayed (planned mitigation)

Preferred Strategy: Direct Replacement of Shell Material with Prepared Coupon.



PNNL coupon panel will go into the middle of one of the large rolled plates-away from welds.

Alternatives:
- **Weld coupon as scab panel to TSC surface.**
- **Apply cold spray and other suitable technology directly to the TSC surface.**

Technical Challenges:
- Ensuring no negative effects to HLC.
- Analysis must support any M&R application.

PNNL Coupon Panel Technology Plan

Task Lead: Ken Ross
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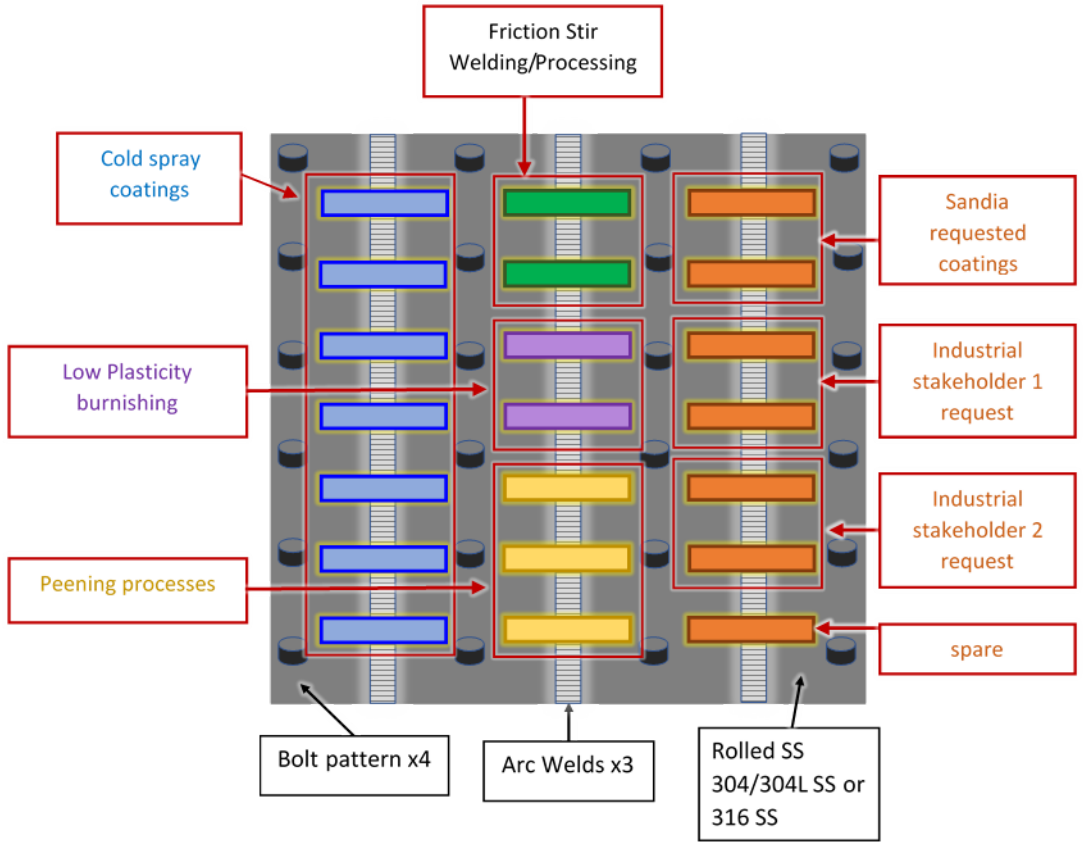


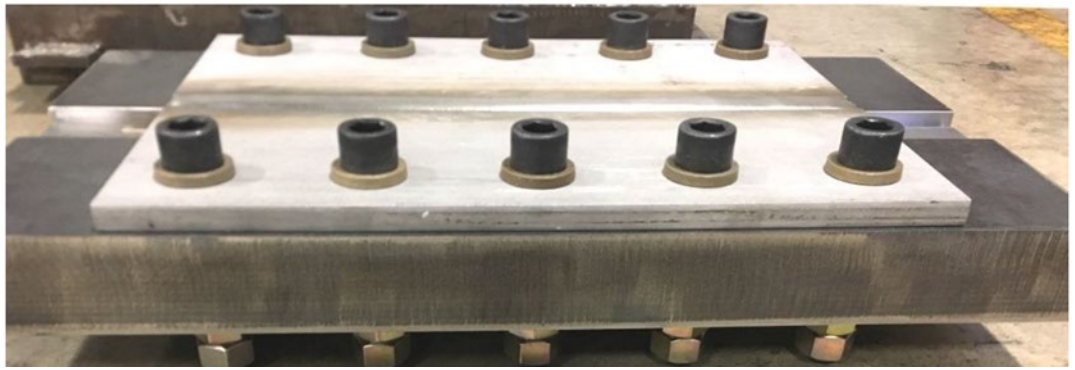
Coupon Panel Priority List (2021)

1) Fabrication welds and base metal
2) Cold spray coatings
3) Peening
4) Friction Stir Welding/Processing (FSW/P)
5) Low plasticity burnishing
6) Stakeholder defined

Technical Challenges:

- Achieving correct residual stress.
- Ensuring no negative effects to HLC.

EPRI Report# 3002018449 2” thick strong back



Thermal Modeling of Canister Systems

Task Lead: Sarah Suffield
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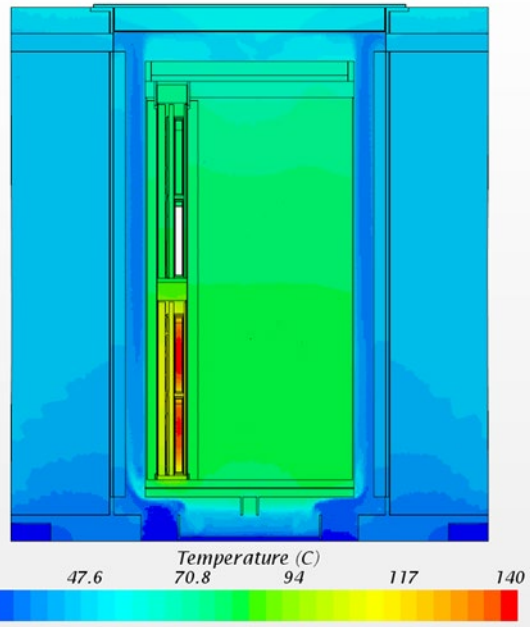
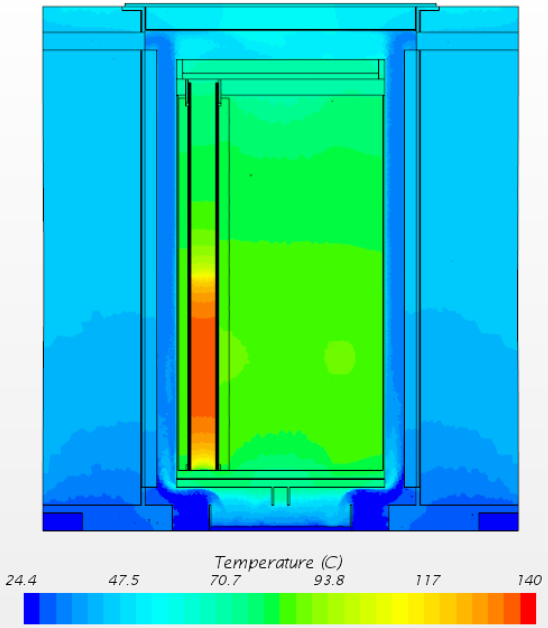
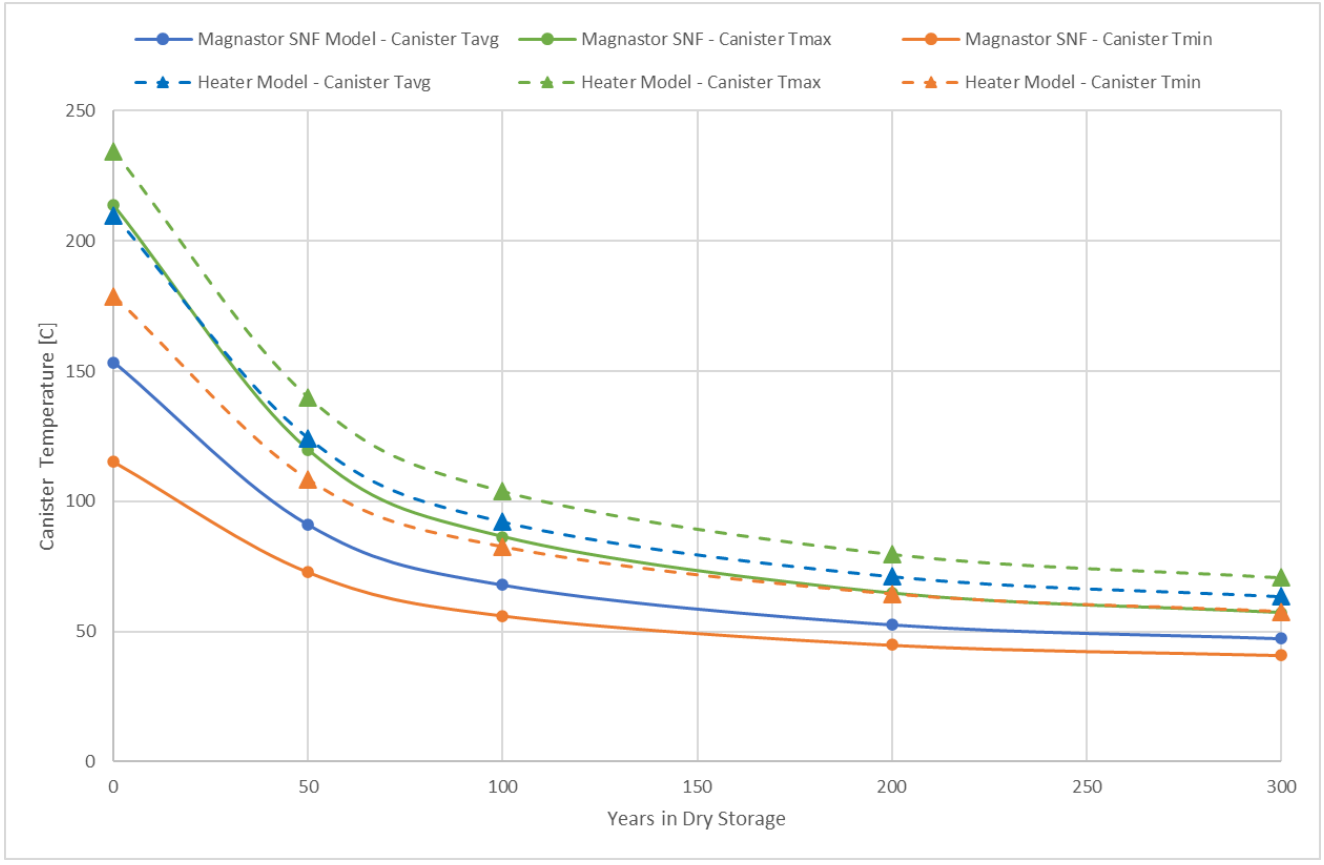
Hanford
Loaded System



Hanford
Heater System



MAGNASTOR SNF Compared to Hanford Canister

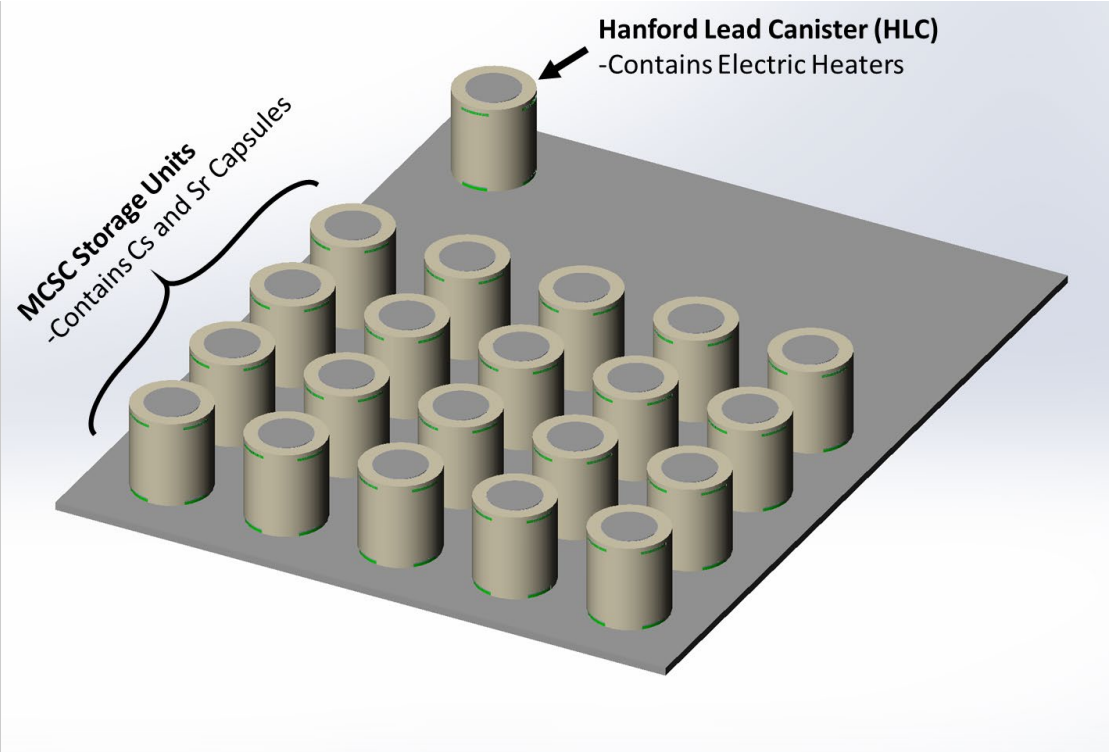


- Validating Thermal Models is Always Beneficial
- (left) Comparing Hanford Capsule Heat Generation to HLC Heaters
- (right) Comparing HLC to Spent Nuclear Fuel Canister System

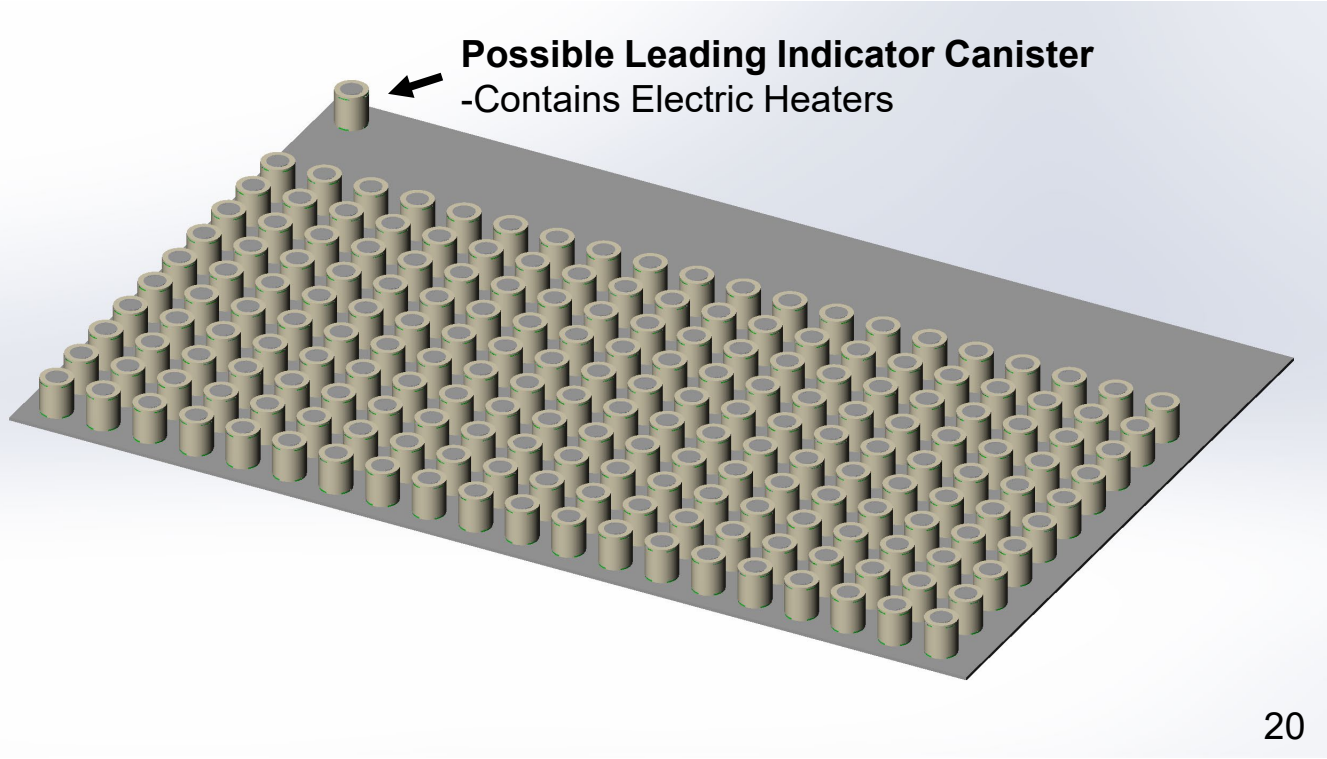
Connection: SNF Consolidated Interim Storage

Information we learn about the HLC and the Hanford canister storage facility could help inform the design and management of a consolidated interim storage facility. While the Hanford canisters will all have similar construction, a consolidated interim storage facility may have a variety of characteristics (design, temperature, pre-existing storage history, etc.).

Hanford Dry Storage Concept



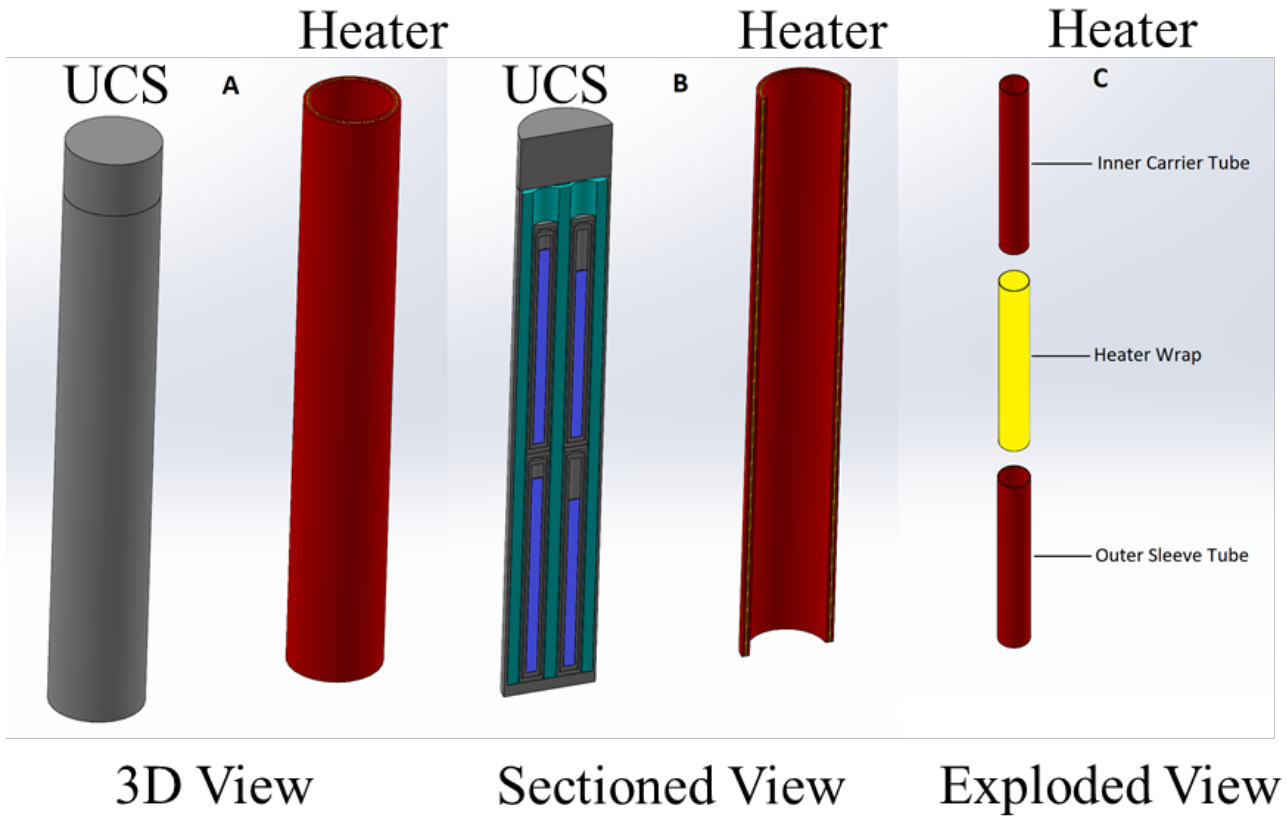
Hypothetical Consolidated Interim Storage Concept

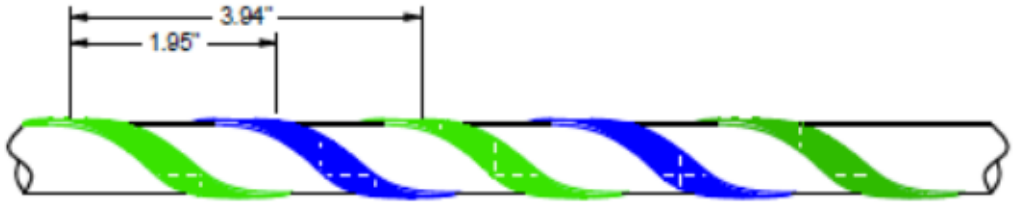


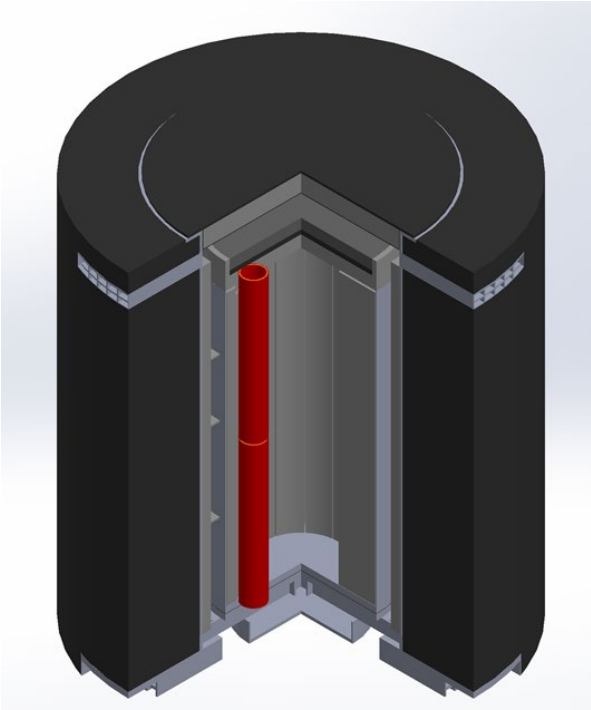
Project Accomplishments and Status

Heater Design Complete

UCS: Universal Capsule Sleeve



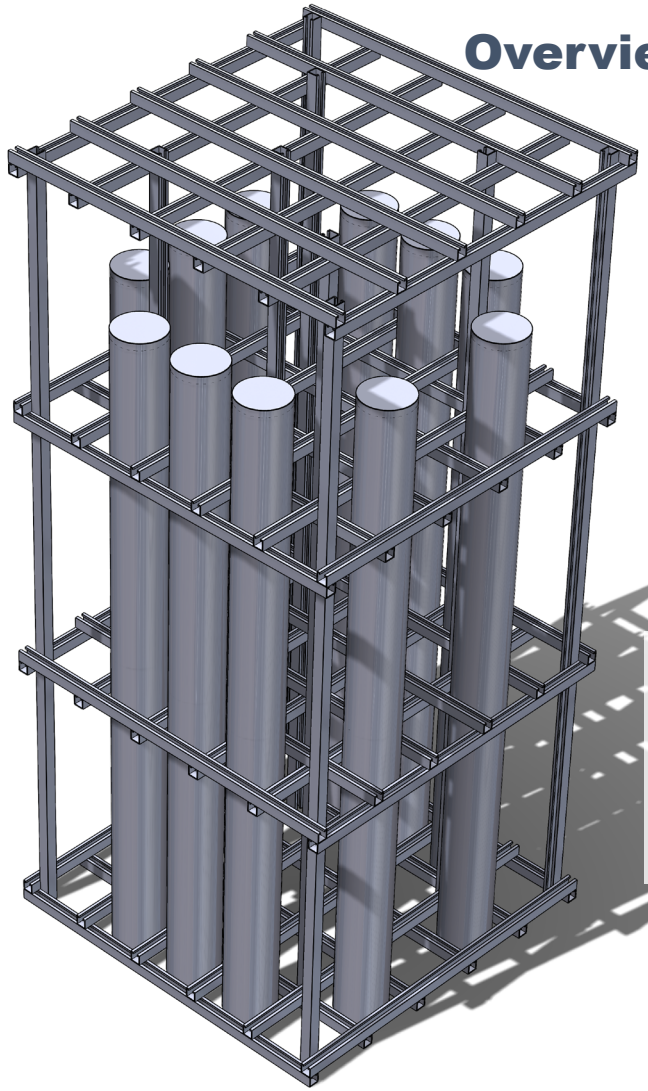


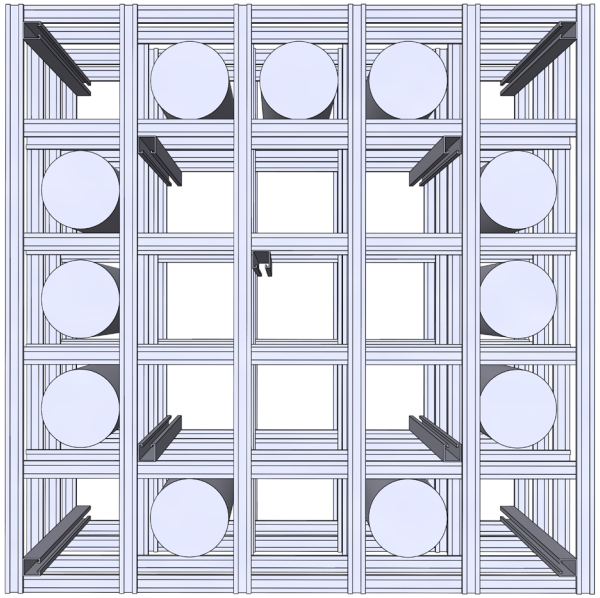


- PNNL designed heaters in 2019-2021
- CPCco purchased heaters from INDEECO
  - INDEECO fabricating in 2021-2022
  - Heaters to be delivered in early 2022
- PNNL will program the control system in 2022
- Bench testing of heaters in early 2022
- Testing of heaters in canister in mid-late 2022

Heater Bench Test Configuration

Overview

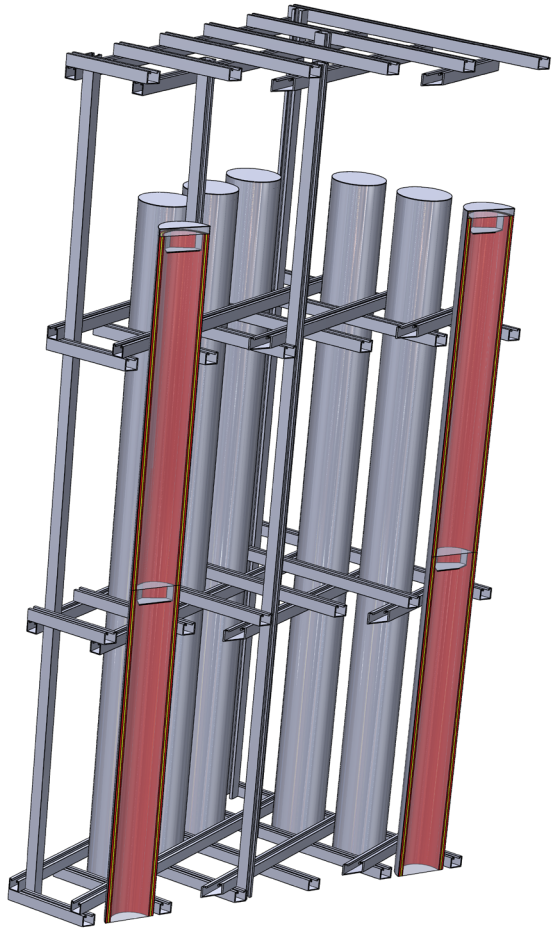


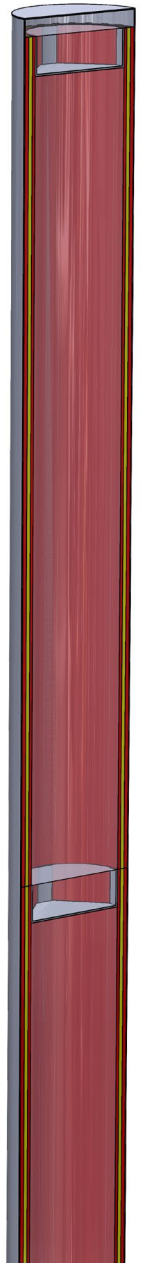


Top view

Stacked heater view

Cutaway view





Unistrut framework holds 22 sleeved heater assemblies in an approximately circular configuration

Heater assemblies are stacked in the sleeves

Bench Test Uncertainty Analysis

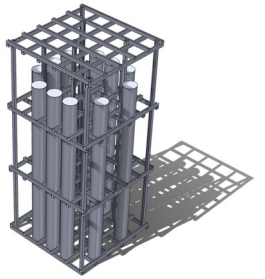
- **Dakota was used to run an uncertainty analysis:**
  - Dakota is a software from Sandia National Laboratories that provides advanced parametric analyses, including quantification of margins and uncertainty with computational models

  - Ran a **latin hypercube sampling (LHS)** statistical method to determine the error bars associated with each component temperature predicted with STAR-CCM+
    - 5 different parameters (Table 1)

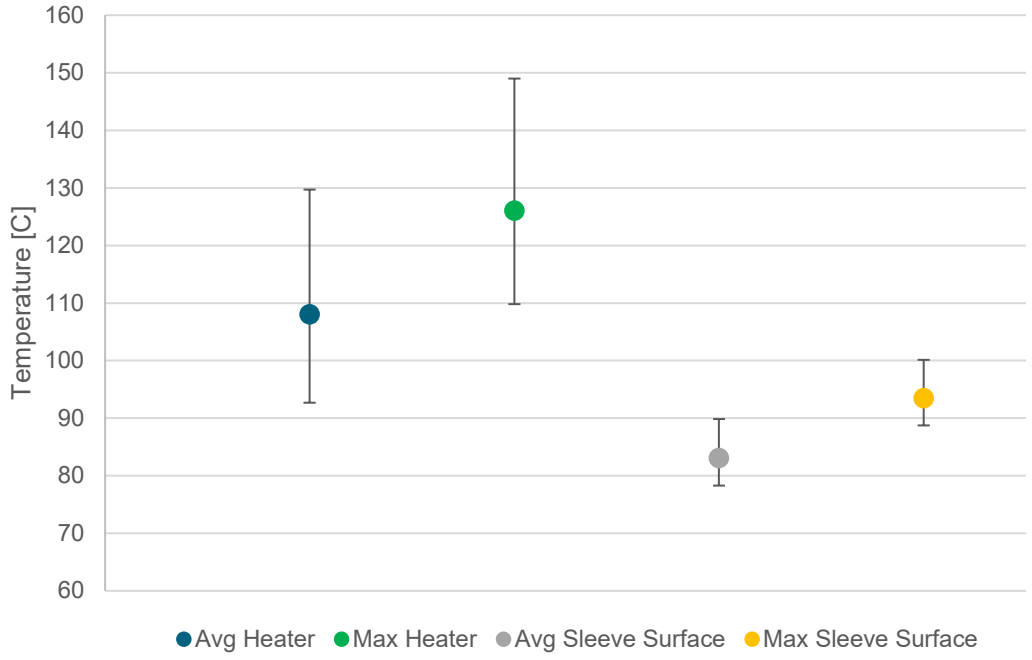
Table 1. Perturbation Parameters

Parameter	Min	Max
Stainless Steel Emissivity	0.17	0.33
Carbon Steel Emissivity	0.52	0.94
Ambient Temperature	60 F	70 F
Radial Gap between Heater and Sleeve	0.01 in	0.25 in
Power/Heat Load	-75 W	+75 W

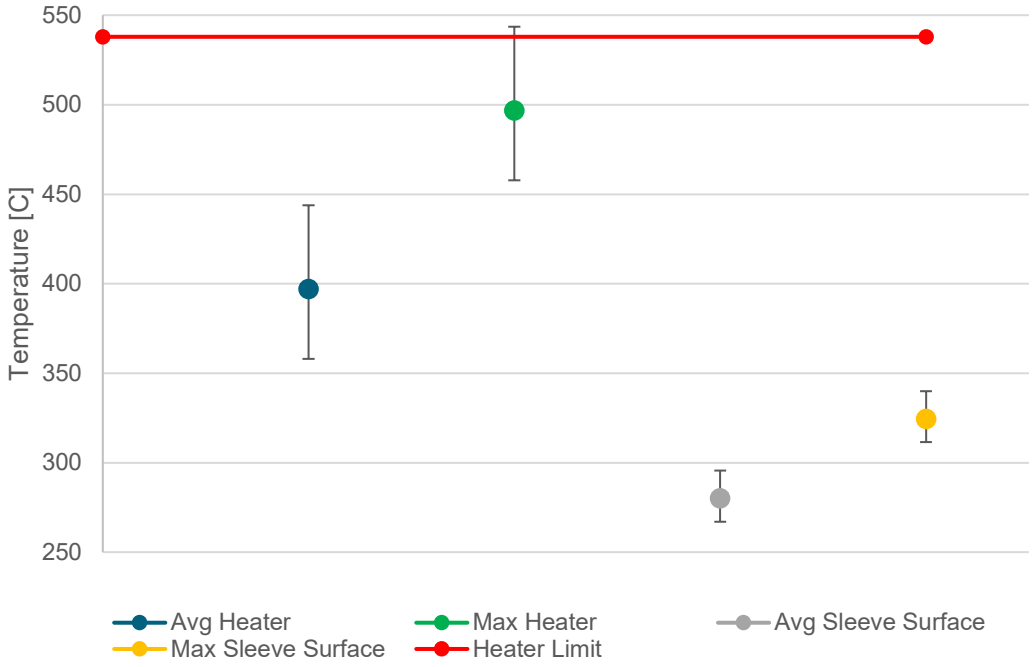
Bench Test Uncertainty Analysis – Model Results



Heater Bench Test @ 3.52 kW



Heater Bench Test @ 24.8 kW



Long Term Test Plan

- **Will Include:**
  - Temperature collection over a long time span.
    - Inlet and outlet temperatures of HLC and all cask systems on site.
    - HLC heater assembly temperatures.
  - Periodic visual inspections.
  - Long term observation of mitigation and repair technologies.
- **Will Potentially Include:**
  - Inlet/outlet air velocity data.
  - Periodic dust sampling.
  - Additional data TBD.

Purpose: All data collected will improve our understanding of the environment that stainless steel nuclear material canisters experience during long term storage conditions.

Closing Remarks

PNNL Team

Integrated Waste Management

Program Leadership
Mark Nutt
Rob Howard
Joe Carter

Hanford Lead Canister Project Team

Task Lead	Thermal Modeling	Heater Design	Heater Control System	Coupon Panels (M&R)
Nick Klymyshyn	**Sarah Suffield**	**Eric Berglin**	**Jake Tucker**	**Ken Ross**
	Christopher Grant	Carl Enderlin		
	Ben Jensen			
	Jim Fort			
	Alec Bovee*			

*Undergraduate intern funded by the DOE Office of Science through the Science Undergraduate Laboratory Internships (SULI) program.

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- We are thankful for the support of our DOE sponsors.

Questions and Discussion