U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Stainless Steel Canister Challenges

Steve Marschman
Field Demonstration Lead
Idaho National Laboratory

NEET ASI Review Meeting
September 17, 2014

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Overview

- **Chloride-Induced Stress Corrosion Cracking (CISCC) has been identified by the NRC as a potential degradation mechanism for welded, stainless steel used fuel canisters (not bare fuel storage casks).**
- **Systems are difficult to inspect and monitor**
- **Three in-service inspections have been performed**
  - Results not conclusive, no cracks seen using visual inspection
  - Chemical analysis of surface samples indicated brackish water sites may not be representative of marine environment
- **Additional work needs to be performed to determine the potential for CISCC to effect used fuel canisters**
- **NRC is evolving expectations for "Lead System Inspections" that will require the industry to "demonstrate that canisters have not undergone unanticipated degradation."**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

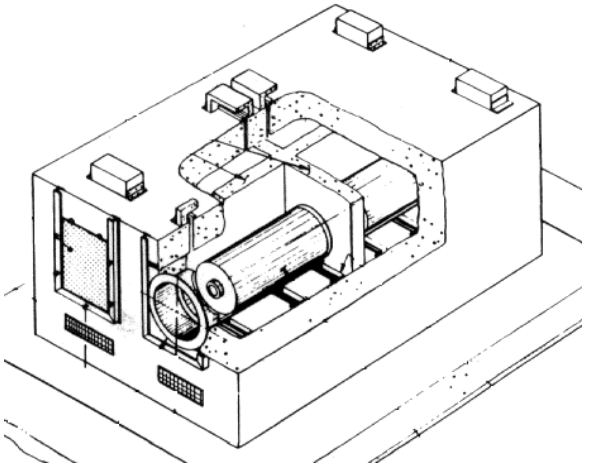
UNF Canisterized Storage Systems

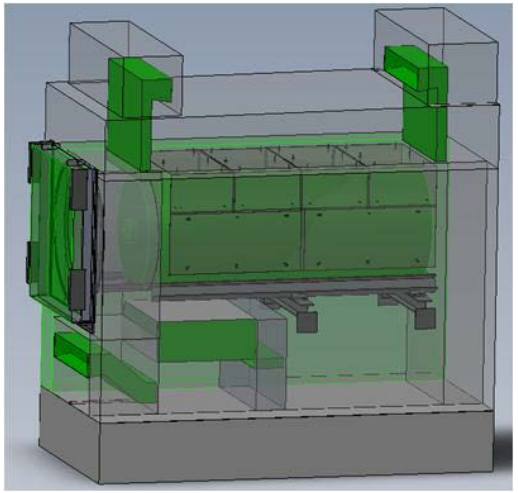
- **Important to understand the systems**
- **One horizontal system (Nuhoms) and multiple vertical systems (Holtec and NAC International)**
- **Limited access – typically vents**
- **Variability in the as-fabricated systems**
  - Not always round
  - Not always square
  - Not always straight
  - Not a lot of room to work in
  - Canisters may not stand or lay straight
- **Environment can be hot, both thermally and radiation**
- **UNF Storage does not generate revenue for the utilities, therefore:**
  - Access is very limited and security restrictions are high
  - Utilities would prefer to keep work within dry storage area to a minimum

- NAC International, Inc.
- UMS (transportable canister in NAC-STC)
- 24 PWR or 56 BWR

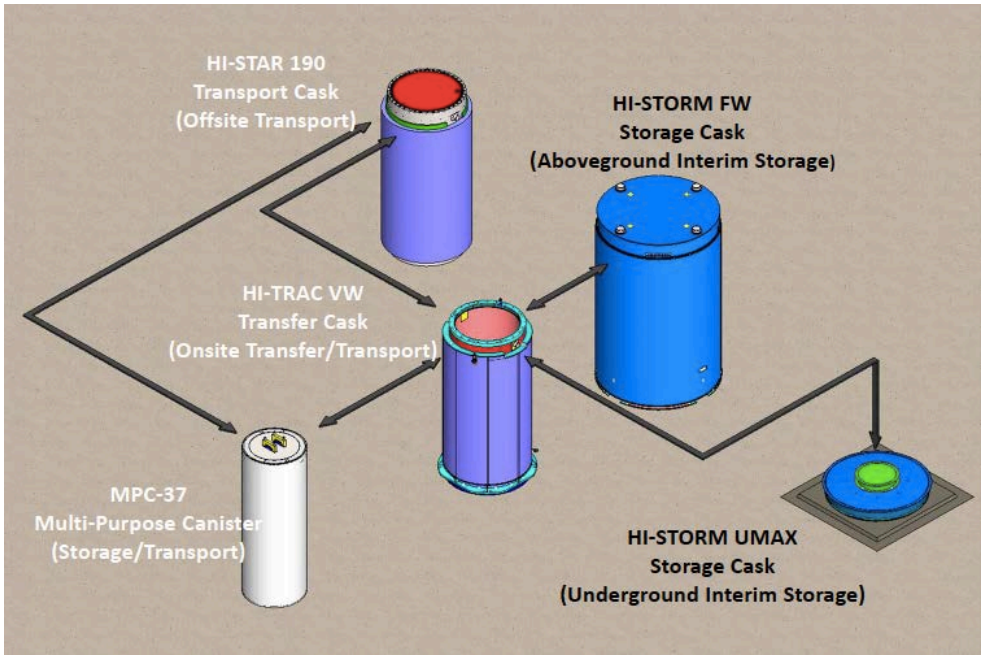
- MagnaStor
- Newly in-service
- 37 PWR or 87 BWR

- AREVA-TN NUHOMS horizontal storage system
- 32-37 PWRs or 61-69 BWRs
- Canisters transferable using MP197HB transport cask

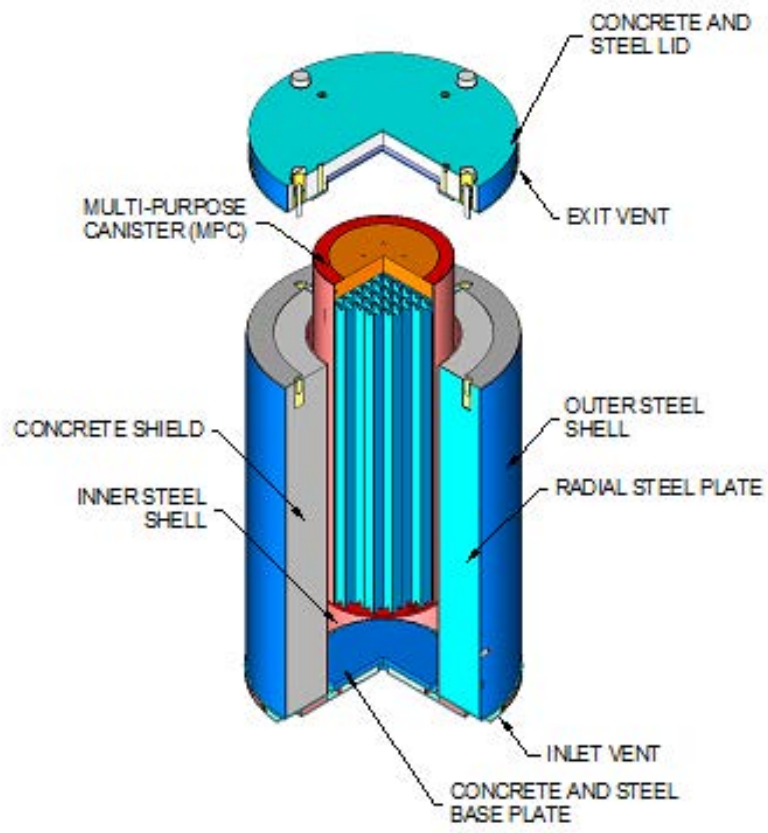


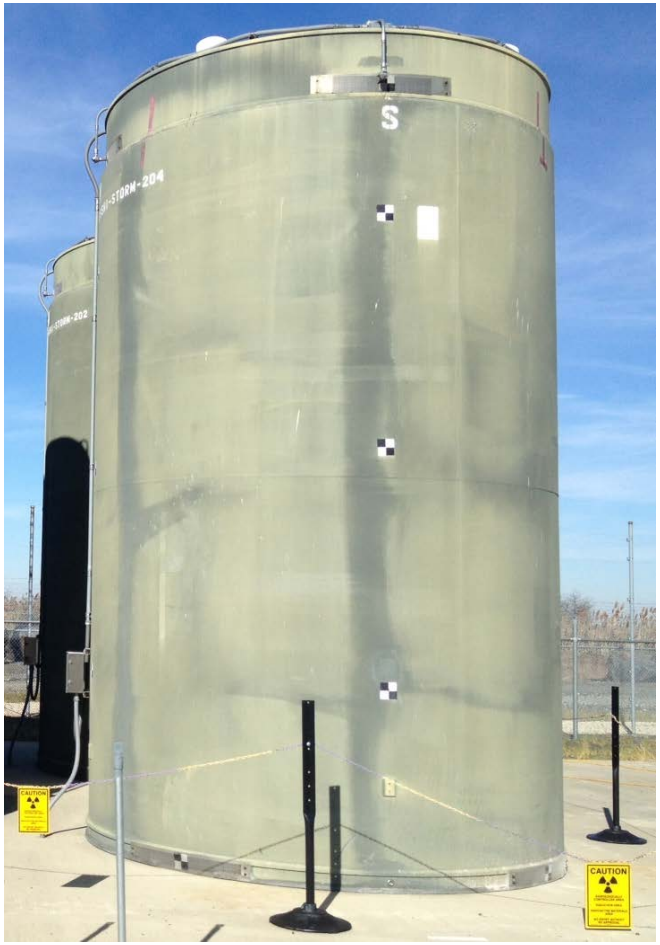


- Holtec International
- 24-32 PWRs or 68 BWRs
- New FW series will hold 37 PWRs or 89 BWRs



- **Holtec Hi-Storm 100**





These two Hi-Storms are not the same. Can you see the differences?

In-Service Inspections

- **EPRI led three examinations (partly funded by DOE); Calvert Cliffs, Hope Creek, Diablo Canyon**
- **Inspections generally consisted of:**
  - Temperature measurements of cask at points inside the annulus between the cask and canister
  - SaltSmart™ measurements in similar locations
  - Dust collection from the cask lid
  - Visual inspection

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Monitoring of Canisterized Storage Systems

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Analyses of Samples Somewhat Disappointing

- Visual Inspection
  - We did not see any evidence of cracking, but did we have good enough imaging capability?
    - Color could be misleading. If something appears orange-brown, is that really corrosion (on SS)?
    - Very limited in surface area that could be covered (particularly for Holtec Hi-Storms)
    - Lighting inconsistent
- Sampling for "Dust"
  - Use of a spun nylon/alumina pad to collect samples was difficult.
    - Hard to get pressure on the surface
    - Some sample falls off
    - Hot canisters partially melted the nylon substrate
  - "Salts" can degrade in handling and shipping; did we alter the sample through the sampling process?
  - Expectation was that all three sites would show evidence of "sea salt," but that was not found
  - Diablo Canyon was the only site with true "sea salt"
  - Calvert Cliffs and Hope Creek, on brackish water sites, were low in Na^+. Did the salt alter due to heat on the canisters? Results were inconclusive.
- SaltSmart Device
  - Used a device outside its design space
  - Effected by heat and gravity
  - Instrument could never be correlated to laboratory analyses.
  - Results inconclusive and not quantitative.
- Conclusion
  - We conclude that we couldn't conclude much about the potential for ClSCC.
    - We need a better way to gather information from canisters

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Present Direction

- **DOE issued IRP-FC-1: Sensors and Delivery Devices for Dry Storage of Used Nuclear Fuel**
  - Recently awarded to team lead by Penn State (Prof. Cliff Lissenden), teamed with University of Illinois, University of South Carolina. Advisory board consists of EPRI, Holtec International, ORNL, PNNL.
  - $3M for a 3 year effort that will:
    - Develop novel in-situ surface composition characterization, nondestructive inspection methods appropriate for the canister using
      - Linear and nonlinear ultrasonic guided waves
      - Ultrasonic nondestructive inspection of bare and clad concrete
      - And a robotically guided wand for access to a harsh and hazardous environment within confined spaces that also provides sensor positional awareness.
- **UFD is funding**
  - Construction of a canister mockup for residual stress analysis.
  - Development of a stress corrosion cracking model for canisters.
- **EPRI is initiating some R&D on SCC detection (unclear which projects may get funding).**
- **NRC has also initiated funding some internal projects related to SCC.**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Challenges to Monitoring

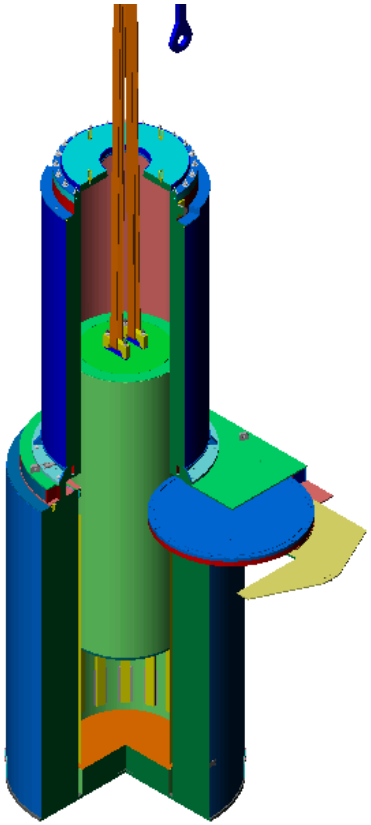
- **Utility's Independent Spent Fuel Storage Installations (ISFSI's)**
  - Regulated by NRC (i.e. 10CFR72)
  - Stringent safeguards and security
  - Very different RadCon requirements from DOE
  - Little to no electrical power (or other services) available on the storage pad
  - Utilities has no desire to allow anything that:
    - Penetrates the confinement boundary of a canister or otherwise presents a risk for radiological release
    - Requires wireless radio (this may change, but has not at this time)
    - Requires a large amount of human interaction
    - Causes them to move anything
    - HOWEVER, change is always possible

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Accessing a Canister

- **Two ways to inspect canisters**
  - Get inside the overpack
  - Open the overpack and remove the canister
- **Both present challenges**
  - We want to solicit ideas for both
  - The IRP is focused on getting inside the overpack
  - There is at least one proposal to remove canisters from overpacks
- **Some things we know:**
  - Canisters do not sit straight
  - Canisters may not be centered
  - Nothing is truly round
  - Tolerances are fairly large

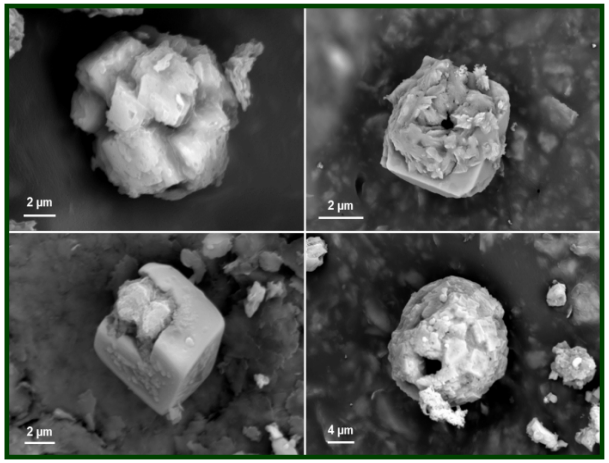


U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Things to Monitor

- **Surface Temperature**
  - Models are getting very good, but temperature is useful for confirmation
- **In-situ Salt Determination**
  - Since “salt aging” may be an issue, can the surface contaminates be characterized and quantified in-situ?
  - Can we determine deposition rates (highly seasonal)?
- **Moisture Analysis**
  - What sticks to the surface and what form is it in (e.g. hydrated species)? And what about relative humidity?
- **Crack Identification and Corrosion**
  - Can we identify pits? Cracks? How small?
  - Can we record where they are so we can look at them again?
  - Can we characterize what is in the pit or crack? Can we learn if a pit or crack will propagate?
  - What else can we do to assess general corrosion?
- **Residual Stress**
  - A stretch goal would be to measure residual stress of welds in-situ.
- **Finally, we always want to know if we are overlooking anything…**



Sea-salt aggregates on in-service Diablo Canyon storage canisters.

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Summary

- Industry has a need to determine if SCC is an issue with stainless steel used fuel canisters
- There are potential opportunities to develop and deploy techniques for monitoring/assessing canisters
- UFD has only limited funding, and other funding sources would be welcome. Collaborations are also welcome.

- For additional information or questions, contact:

Steve Marschman

steve.marschman@inl.gov

208.526.2335