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# Stainless Steel Canister Challenges

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# 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."**

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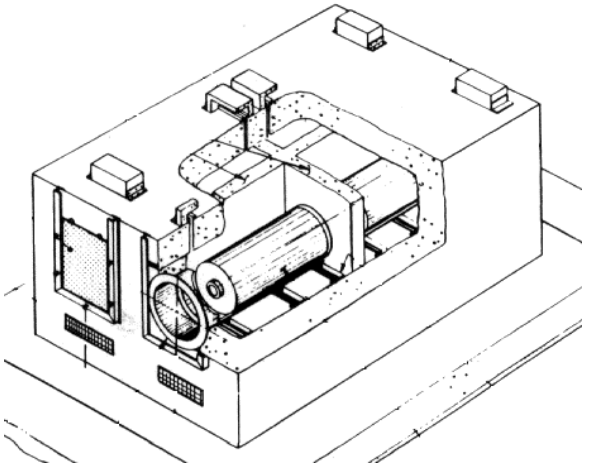
# UNF Canisterized Storage Systems

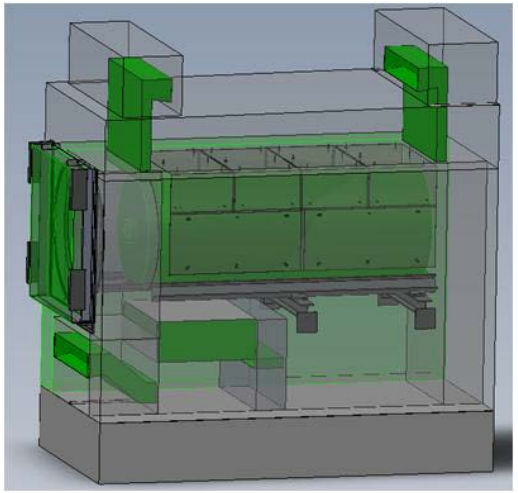
- **Important to understand the systems**
- **One horizontal system (Nuhoms) and multiple vertical systems (Holtec and NAC International)**
- **Limited access – typically vents**
- **Variability in the as-fabricated systems**
  - Not always round
  - Not always square
  - Not always straight
  - Not 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

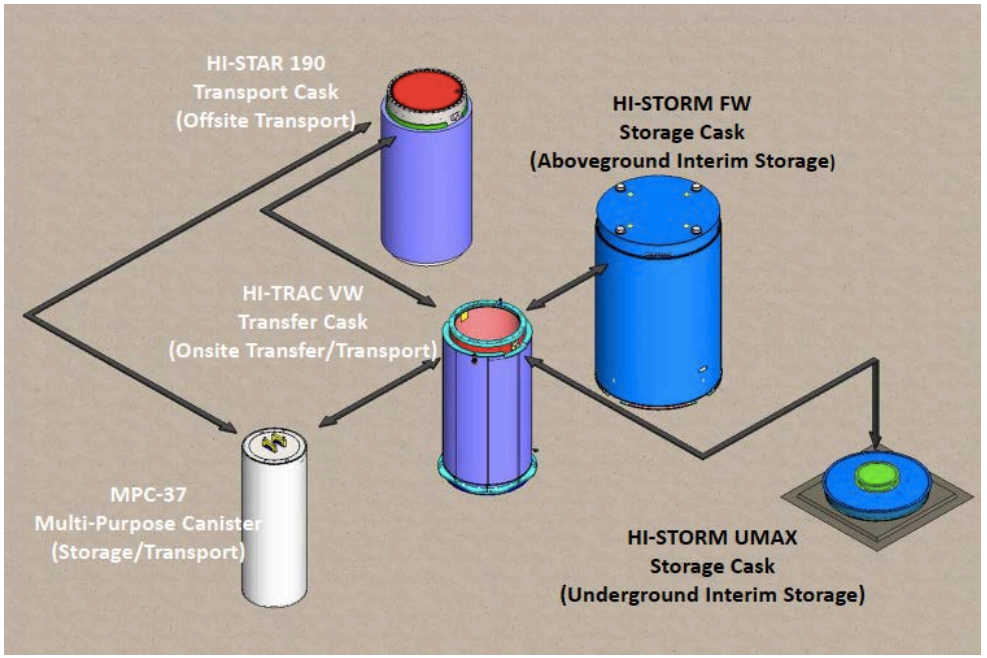
- MagnaStor
- Newly in-service
- 37 PWR or 87 BWR

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

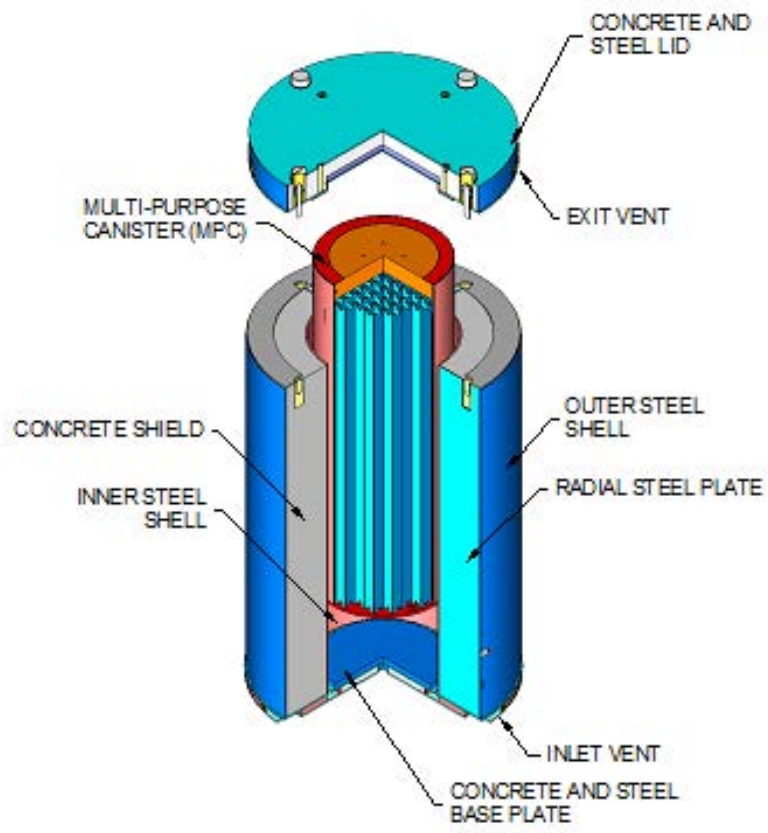




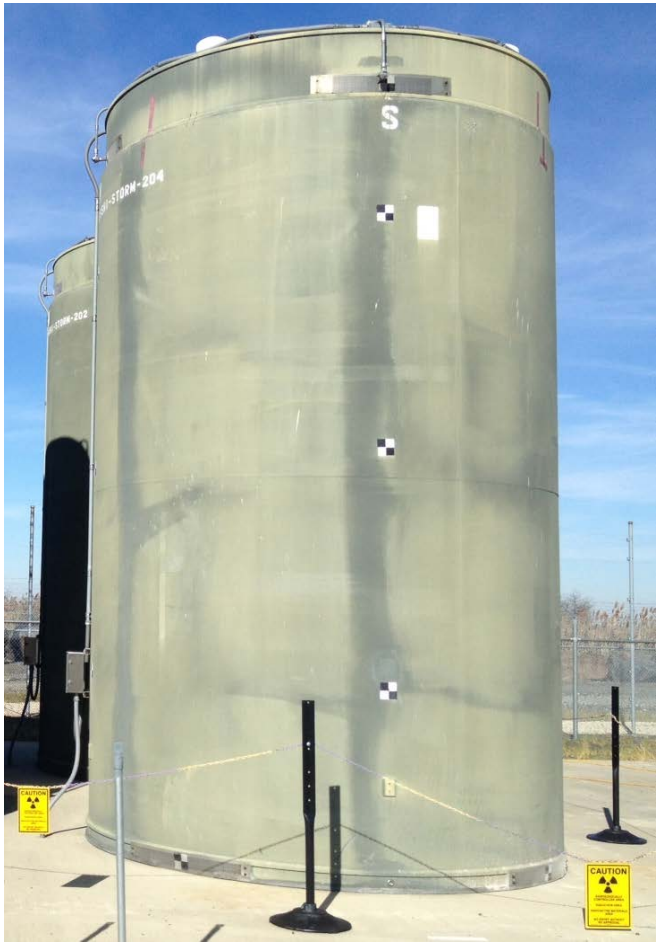
- Holtec International
- 24-32 PWRs or 68 BWRs
- New FW series will hold 37 PWRs or 89 BWRs



- **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



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# Monitoring of Canisterized Storage Systems



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# 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

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# 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.**

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# 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

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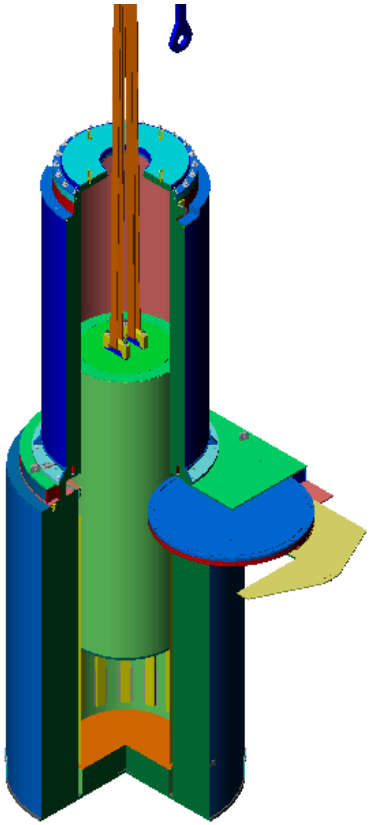
# Accessing a Canister

- **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



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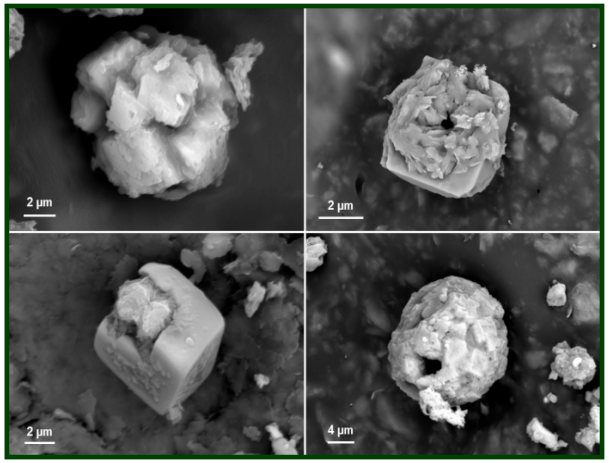
# Things to Monitor

- **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.*

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# 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:

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