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Understanding the Risk of Chloride Induced Stress Corrosion Cracking

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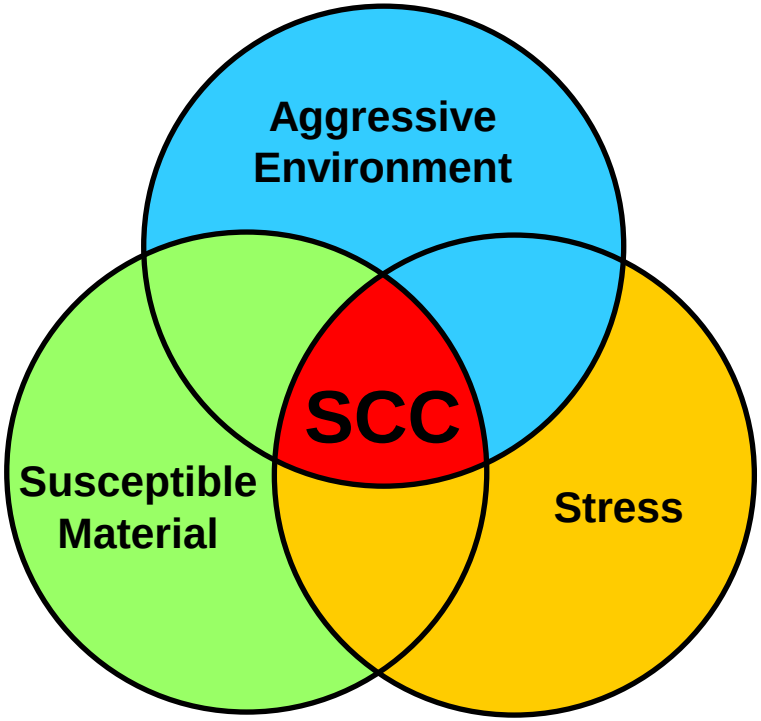
Understanding and Addressing Data Gaps for Chloride Induced Stress Corrosion Cracking (CISCC)



- What is the environment on the surface of dry storage canisters and how does it evolve with time?
- Is there sufficient stress to support through-wall stress corrosion cracks, and if so, what is the magnitude?
- Generically, what are the crack growth kinetics given the known physical and environmental conditions of dry storage casks?

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Understanding the Surface Environment: *Samples from Container Surfaces*

- **Samples acquired from three different nuclear power stations were provided by EPRI for analysis**
- **Dust and salt loads were high on canister upper surfaces, but low on vertical surfaces.**
- **Near-marine site 1 (approximately 0.5 miles from brackish water)**
  - Soluble components largely calcium and sulfate with little chloride
- **Near-marine site 2 (approximately 0.25 miles from brackish water)**
  - Soluble components largely calcium, sulfate, and nitrate with little chloride
- **Marine site (approximately 0.35 miles from the ocean)**
  - Sea-salt aerosols, occurring as aggregates of NaCl and Mg-sulfate with trace amounts of K and Ca, were a major component of the dust samples.

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Understanding the Surface Environment: *Salt and Brine Stability*

- **Once deposited on the surface of a storage container, there are numerous processes that will affect the composition of the species that remain**
  - Gas to particle conversion reactions
  - Acid degassing
  - Ammonium mineral decomposition and brine degassing
- **On a hot canister, prior to deliquescence, NH_4NO_3 and NH_4Cl will not persist. If deposited, other chloride salts will accumulate, and $(NH_4)_2SO_4$ may accumulate.**
- **However, upon deliquescence, brines containing NH_4^+ and NO_3^- or Cl^- will rapidly degas until either NH_4^+ or (NO_3^- + Cl^-) are consumed.**
- **Consider a deliquesced $(NH_4)_2SO_4$ brine:**

$$(NH_4)_2SO_4 + NaCl \rightarrow \tfrac{1}{2}Na_2SO_4 + \tfrac{1}{2}(NH_4)_2SO_4 + NH_3(g) + HCl(g)$$

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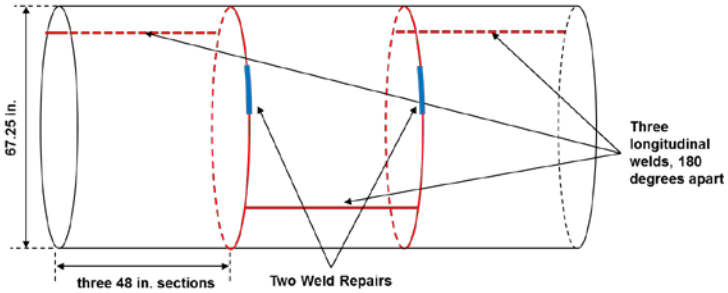
Understanding the Residual Stress State in Fielded Dry Storage Containers

- **Propagation of a stress corrosion crack requires the presence of a sufficiently large stress**
  - Residual stresses associated with welds
  - Residual stresses associated with forming process
- **Stresses will vary based upon the type of weld**
  - Longitudinal vs. Circumferential
  - Weld repairs
- **Mock container assembled and being evaluated**
  - Deep hole drilling
  - Contour measurement + x-ray diffraction
  - Electrochemical properties



- Wall material: 304 SS (dual certified 304/304L) welded with 308 SS
- Geometry mimics NUHOMS 24P container
- Welds are Full penetration and inspected per ASME B&PVC Section III, Division 1, Subsection NB (full radiographic inspection)

- **Once analyzed, container will be sectioned and used as samples for the UFD and NEUP programs**

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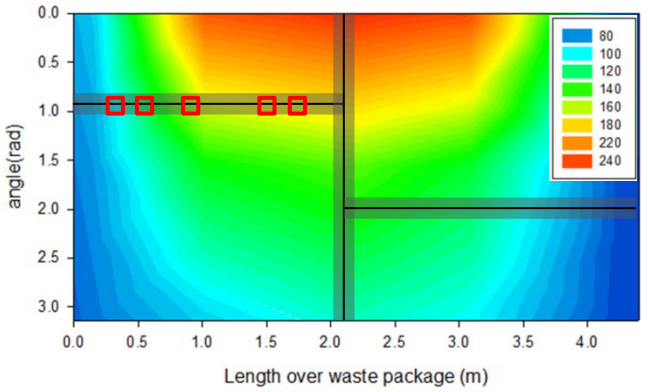
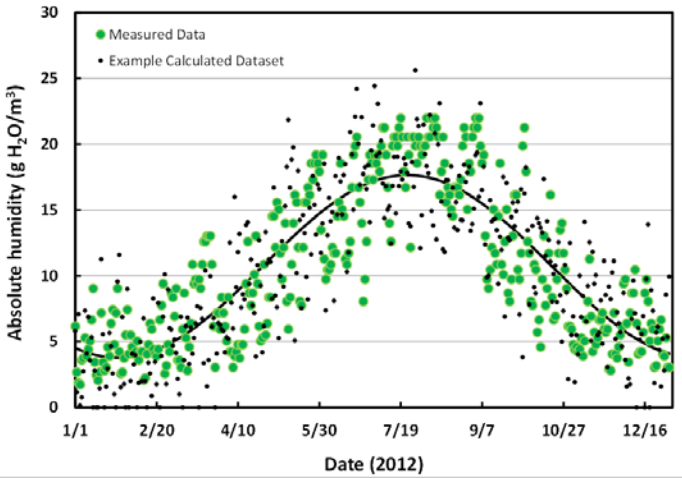
Development of a Probabilistic Stress Corrosion Cracking Model for SNF Interim Storage Canisters

- **Goal—identify most important parameters for evaluating canister SCC performance (penetration times).** ***Used to prioritize research needs*****.**
- **Current model is simplified—not intended to accurately predict canister performance, but only to develop the functional form and data needs for the model.**
- **SCC model based on approach by Turnbull et al. (2006a, b)**
  - Assumes SCC initiates from localized corrosion pre-cursors (corrosion pits)
- **Submodels**
  - Pitting initiation model
  - Pitting growth model
  - Model for pit-crack transition
  - Model for crack growth



Surface temperature estimates



Site-specific National Weather Service data

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