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Canister Confinement Integrity

Integrated Plan for Addressing Potential Chloride-Induced Stress Corrosion Cracking of Austenitic Stainless Steel Dry Cask Storage System Canisters

Keith Waldrop, Christine King, Shannon Chu
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NEI Used Fuel Management Conference
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Background

- Need for extended storage
- How do we get there
  - Evaluate R&D data gaps
    - Gap analyses: NWTRB, DOE, NRC, EPRI, International
  - Perform R&D
    - EPRI led Extended Storage Collaboration Program (ESCP)
  - Integrate results
- EPRI's gap analysis (EPRI Report 1022914, Aug 2011)
  - Only high priority gap is SCC of welded SS canisters

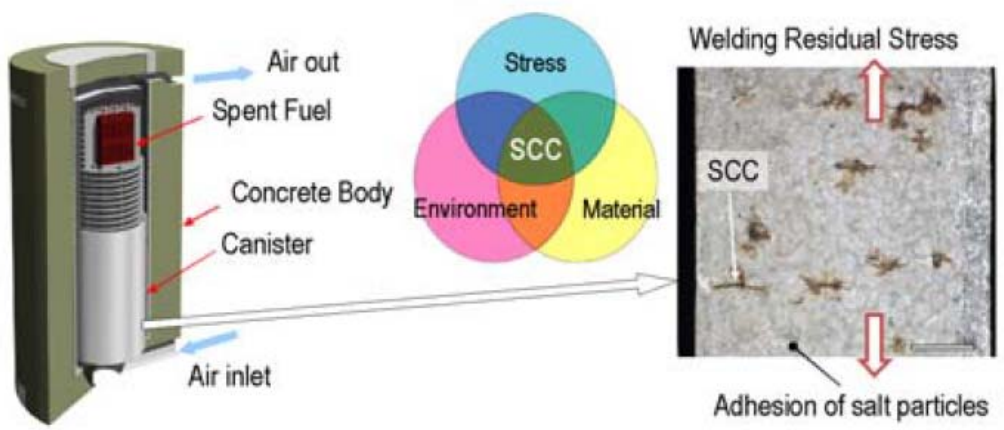
For canister confinement integrity:

Focus on potential for CISCC of welded stainless canisters

Stress-Corrosion Cracking (SCC) of SS Welded Canisters

SCC requires 3 concurrent conditions:

1) Austenitic stainless steels (e.g. 304, 316)
2) Tensile stress (residual weld stress)
3) Corrosive environment
   - Salts in the air
   - Deliquescence
     - Surface temperature
     - Humidity



SCC can occur *under conservative lab conditions*

What we don't know …
What are the conditions on actual canisters?

Approach

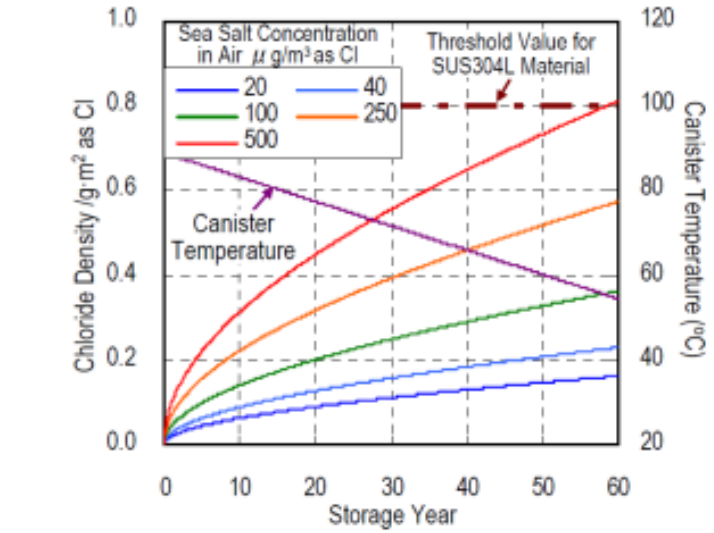
High level view:

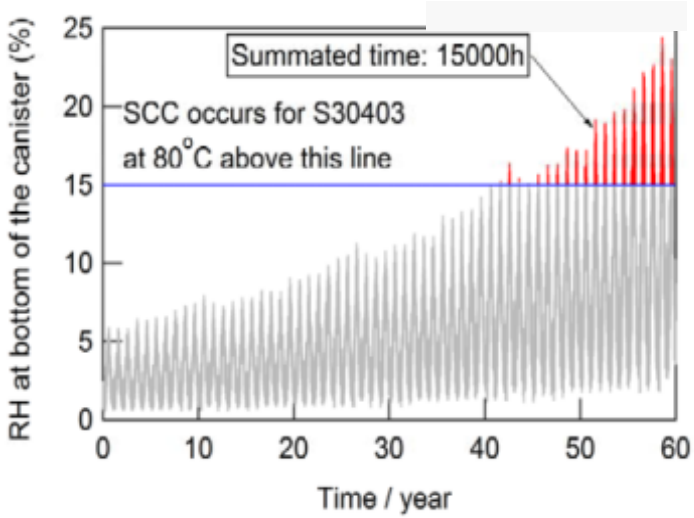
- Understand conditions*
- Understand effects *
- Identify susceptibility *
- Identify options to address
- Develop plan to address

* - Included in Chloride Induced Stress Corrosion Cracking RIRP (ML13042A090) and EPRI R&D Roadmap (ML13042A140)

Understand Conditions

- Voluntary Inspections
  - Initial Inspection plans
    - Scope:
      - Visuals
      - Surface deposit sampling
      - Atmospheric sampling
    - 3 Locations
      - Calvert Cliffs (complete)
      - Hope Creek (3rd Qtr 2013)
      - Diablo Canyon (3rd Qtr 2013)
- Lab experiments
  - Identify conditions for SCC





Figures: SCC Evaluation Method of Multi-Purpose Canister in Long Term Storage, Central Research Institute of Electric Power Industry

Understand Effects

Failure Modes and Effects Analysis (FMEA)

- Systematically identify credible failure modes for SS canisters
- Identify range of potential effects for failure mode(s)
  - Fault Tree Analysis of failure modes to evaluate combinations of initiating events
  - Frequency / probability of failure mode occurrence as a function of time
  - Consequences associated with the failure mode
  - Detection before the impact of the effect is realized
- Literature survey
  - Identify knowledge gaps between actual conditions vs. degradation data available
- Degradation models
  - Conditions for initiation
  - Propagation and growth rate

Understand Effects

Failure Modes and Effects Analysis (con't)

- Scope of this effort is limited to welded SS canister designs exposed to atmosphere
- Focus on aging-related degradation
- Incorporate results from gap analyses done by others
- Existing design basis documents for volunteer plant will be reviewed and factored into the failure modes considered

Identify Susceptibility

Industry-wide Susceptibility Criteria

- Develop criteria to assess susceptibility of ISFSIs to canister degradation, potentially leading to a loss of confinement integrity
- Identify the associated time scales
- Interaction between relative humidity, salt concentration, and local temperature due to decay heat may combine to create a window of concern for susceptibility
- Advisory panel will oversee development of susceptibility assessment methodology
  - Utilities, vendors, consultants, NEI

Identify Options to Address

Inspection – Monitoring - Mitigation

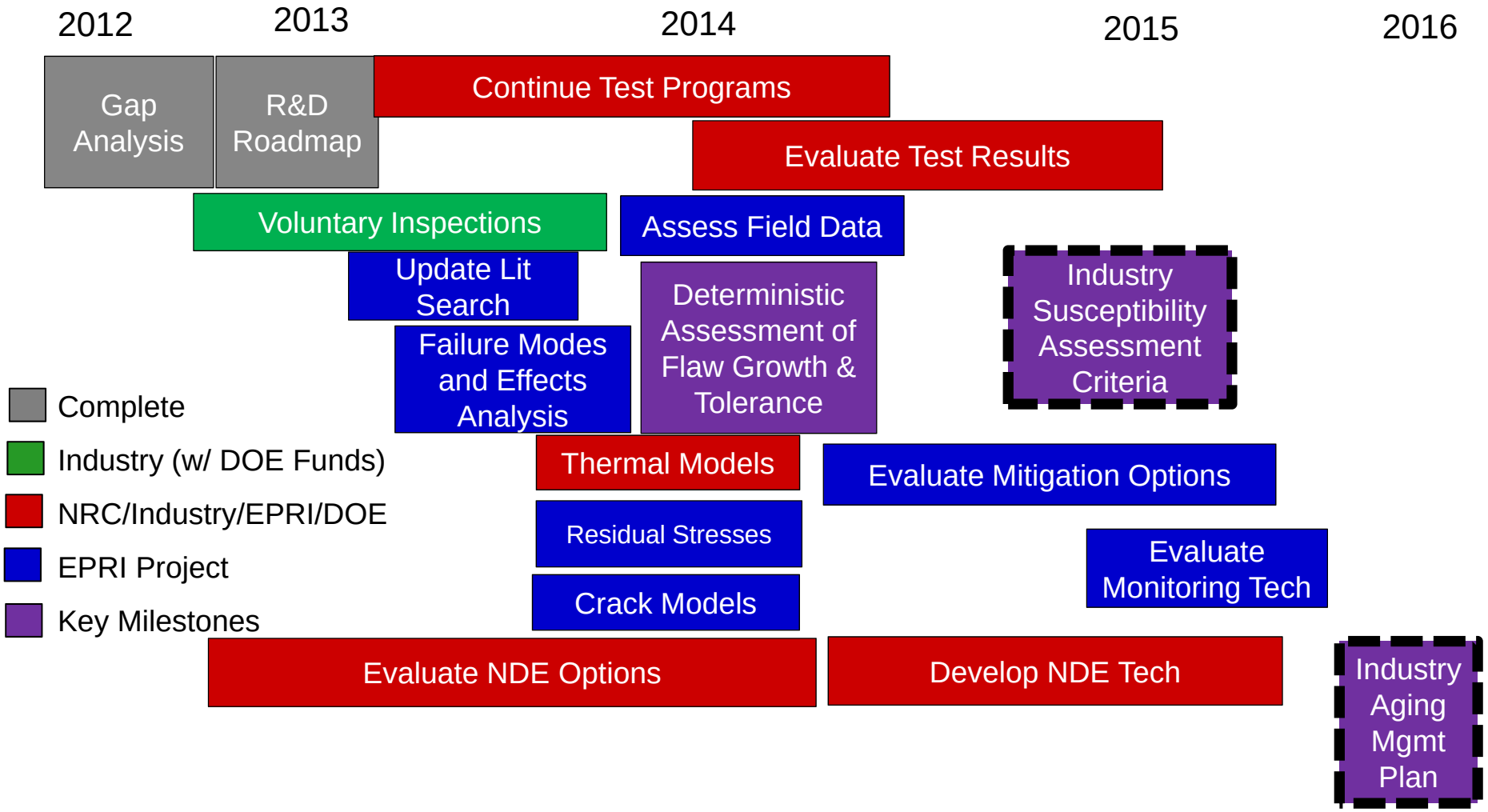
- Stainless Steel Canister Confinement Integrity Assessment
  - Probabilistic models of environment and crack behavior applied to determine recommended inspection frequencies
- Simultaneous effort to identify, develop, evaluate:
  - NDE Technologies
  - Monitoring Technologies
  - Mitigation Technologies

Develop Plan to Address

- Develop Aging Management Plan
  - Provide to industry
  - The aging management plan will guide industry activities including inspection schedules and potential application of mitigation techniques to canisters
  - Publish guidance document early 2016
- Develop site specific aging management plans

Utilities incorporate appropriate management strategy into site plans

Project Overview



Initial Steps

- Key Dates for Susceptibility Assessment (Estimates)
  - FMEA of Stainless Steel Canisters
    - Draft 9/13
    - Final 12/13
  - Deterministic Assessment of Canister Flaw Growth and Tolerance
    - Draft 1/14
    - Final 4/14
  - Industry Susceptibility Assessment Criteria
    - Outline 5/14
    - Draft 12/14
    - Final 6/15

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