



Addressing CISC as a Potential Aging Effect for Welded Stainless Steel Dry Storage Canisters

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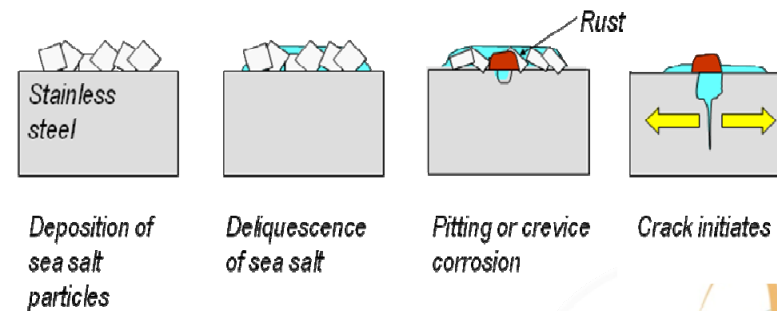
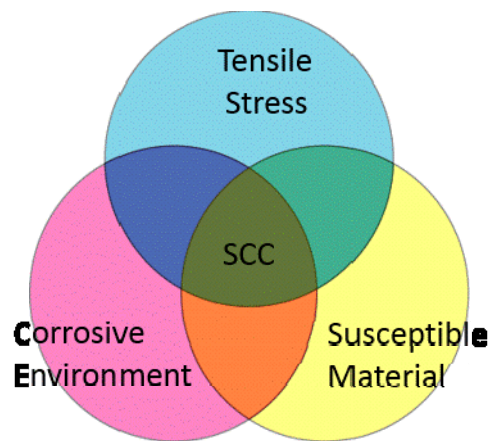
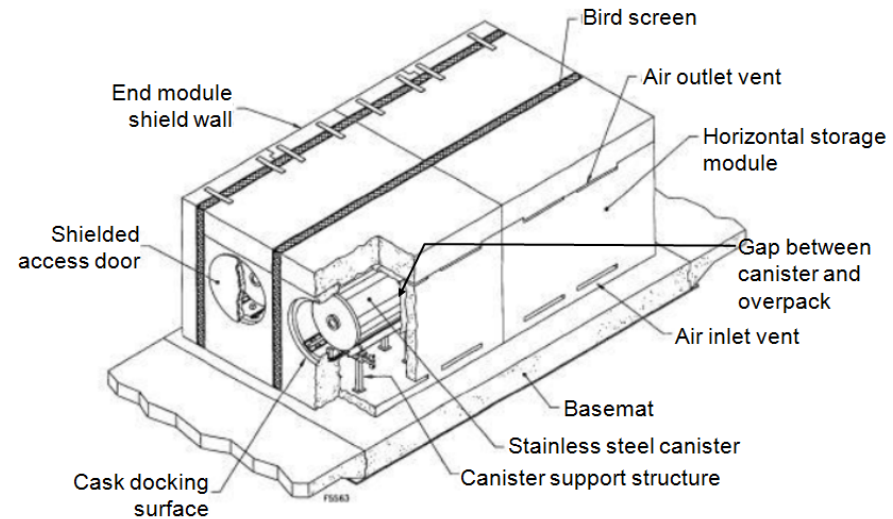
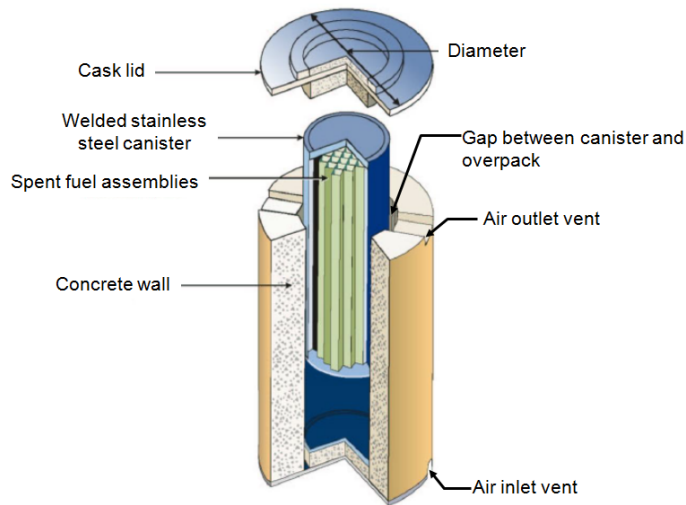


Outline

- Potential for chloride induced stress corrosion cracking (CISCC) of welded stainless steel canisters
- Summary of NRC test results
- NRC review of the Electrical Power Research Institute (EPRI) report on CISCC Susceptibility Assessment
- Example aging management program (AMP)
- ASME Code Case
- Current NRC sponsored efforts
- Risk informing aging management



Potential for CISCC of Welded Stainless Steel Canisters



NRC Test Results

- NUREG/CR-7030 (ML103120081) Published Oct 2010
 - 304, 304L and 316L stainless steels susceptible to CISCC
 - CISCC can only occur when chloride containing salts are present and the relative humidity is sufficient for salt deliquescence
- NUREG/CR-7170 (ML14051A417) Published Feb 2014
 - Effects of surface chloride concentrations and applied stresses
 - Environmental conditions limit temperature range for CISCC
 - Thermally sensitized materials more susceptible to CISCC
 - Salts that do not contain chloride do not promote CISCC



NRC Public Meeting Presentations



- August 5, 2014 NRC public meeting (ML14258A081)
 - Chloride-Induced Stress Corrosion Cracking Tests and Example Aging Management Program (ML14258A082)
 - Reactor operational experience with welded stainless steel tanks and piping systems affected by atmospheric CISCC
- April 21, 2015 NRC public meeting (ML15146A090)
 - Example AMP for Localized Corrosion and Stress Corrosion Cracking of Welded Stainless Steel Dry Storage Canisters (included in ML15146A115)
 - Effects of atmospheric conditions and surface deposit chemistry on the potential for CISCC



Industry Reports and Products



Electrical Power Research Institute (EPRI)

- Failure Modes and Effects Analysis (FMEA) of Welded Stainless Steel Canisters for Dry Cask Storage Systems, EPRI-3002000815, December 2013.
- Literature Review of Environmental Conditions and Chloride-Induced Degradation Relevant to Stainless Steel Canisters in Dry Cask Storage Systems, EPRI-3002002528, May 2014.
- Flaw Growth and Flaw Tolerance Assessment for Dry Cask Storage Canisters, EPRI-3002002785, October 2014.
- **Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems, EPRI-3002005371, September 2015**

Nuclear Energy Institute (NEI)

- Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management, NEI 14-03 Rev 1, September 2015 (ML15272A332)

Institute of Nuclear Power Operations (INPO)

- Industry Dry Cask Storage OE Database (in development)



NRC Comments on the EPRI CISCC Susceptibility Report



NRC Comments on EPRI-3002005371, September 2015

Letter: ML16032A558, Comments: ML16032A564

- Approach to ISFSI and canister ranking with identified geographic, atmospheric, material, system design and operational parameters
- NRC comments focused on model parameters, parameter interactions, discussions where additional detail may be beneficial and potential regulatory considerations
 - Fabrication effects and residual stress
 - Local chloride and water vapor sources on environmental parameters
 - Cooling tower water chemistry
 - Incorporating operating experience and new information
 - Susceptibility assessment criteria validation



NRC Example AMP Development



- Aging management programs (AMPs) and time limited aging analyses (TLAAs) are required to address aging effects for important to safety structures, systems and components (10 CFR 72.42, 10 CFR 72.240)
- Example AMPs provided in NUREG-1927 Rev 1 as guidance for both NRC reviewers and applicants
 - Example AMP for Localized Corrosion and Stress Corrosion Cracking of Welded Stainless Steel Dry Storage Canisters
- Intended to be examples, not the only acceptable approach



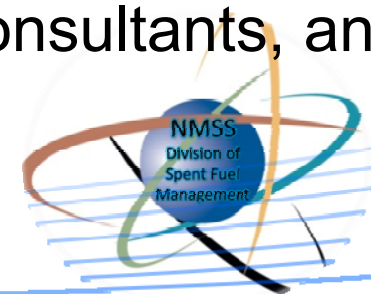
Example AMP Considerations

- SCC can initiate from pitting and crevice corrosion
- Corrosion products can be detected by remote visual inspection
- Acceptance Criteria from the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel code (B&PV) Section XI IWB-3514 and IWB-3640
 - Selected based on material and component function
 - ASME Code Case under development
- Use of surface or volumetric non-destructive examination (NDE) methods viewed as a delivery system challenge
- EPRI CISCC Susceptibility Report methodology for canister selection and criteria for bounding analyses
- Public comments on NUREG-1927 Revision 1



ASME Code Case

- NRC requested ASME to develop consensus code case for inservice inspection (ISI) of spent fuel storage and transportation containments
- Leverage extensive experience to develop methodology to inspect, assess, & require corrective actions (repair, replace, and/or mitigate)
- ASME Section XI created a new Task Group to develop the ASME code case
- Participants include NRC staff, dry storage system vendors, NRC licensees, EPRI, industry consultants, and DOE laboratory staff



Current NRC Sponsored Efforts



- Application of NDE to dry storage systems
 - Welded stainless steel canisters
 - Concrete shielding structures
 - Ability of NDE methods to identify and characterize aging effects in containment and shielding structures
 - Implementation challenges to specific designs
- Review of specific systems
 - Focus on systems that are expected to be included in site specific or CoC renewal applications
 - Aging management tables
 - Example aging management programs



Risk Informing Aging Management Activities

- Probability of aging mechanisms
- Consequences of aging effects
- Operational experience
- Regulatory requirements

