ELECTRIC POWER
RESEARCH INSTITUTE

January 31, 2013

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Subject: Transmission of EPRI's R&D Roadmap to Address Potential Stress-Corrosion Cracking of Welded Stainless Steel Used Nuclear Fuel Dry Storage Canisters

Dear Mr. Pstrak:

On December 18, 2012 NRC held a public meeting on the chloride-induced stress-corrosion cracking (CISCC) RIRP issue. At that meeting EPRI made a presentation on its overview for an Aging Management Plan, including an R&D roadmap to address the potential for CISCC of welded stainless steel dry storage canisters. Also, at that meeting, EPRI made a commitment to provide NRC with a draft roadmap by the end of January.

Attached is EPRI's draft R&D roadmap on this issue. We welcome NRC's comments on the roadmap and would be willing to discuss the roadmap with NRC staff in the near future. Please contact me if you have any questions or comments.

Sincerely,

Keith Waldrop
Senior Project Manager

KPW

Attachment

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ATTACHMENT

USED FUEL DRY STORAGE STAINLESS STEEL CANISTER STRESS CORROSION CRACKING SUSCEPTIBILITY ASSESSMENT:

R&D ROADMAP LEADING TO IDENTIFICATION OF CANISTERS POTENTIALLY SUSCEPTIBLE TO STRESS-CORROSION CRACKING

Rev. 0 (1/31/13)

1. INTRODUCTION

There are over 1300 welded stainless steel (SS) dry storage canisters in the United States into which the spent fuel assemblies have been placed. These canisters provide the primary confinement barrier to prevent release of radionuclides into the environment. Several studies have identified the possibility for these canisters to be affected by stress corrosion cracking (SCC) if located in a marine atmosphere (near the ocean) [EPRI 2005, Tani and Myuzimi 2005]. Other studies have since confirmed cracking of stainless steel can occur under certain conditions, including studies sponsored by NRC [NRC 2010; NRC 2012]. This issue has also been identified as a high priority data gap in several gap analyses conducted to develop the technical basis for the extended storage of fuel in dry storage beyond the current licensing periods of 20 to 60 years [NWTRB 2010; DOE 2012; NRC 2012; EPRI 2011].

Interest in the potential for this phenomenon to affect dry storage canisters prompted it to be addressed by industry and NRC as a pilot issue in the Used Fuel Storage and Transportation Regulatory Issue Resolution Protocol (RIRP) process in 2011 [NEI 2011]. The issue has been characterized as a lack of sufficient data to determine under what conditions (environmental and cask), and over what time scales SCC could initiate. As part of the resolution plan, industry volunteered to perform in-situ inspections of actual canisters. Data from these inspections, when combined with additional laboratory R&D and data from further literature searches, should enable industry and the NRC to determine the conditions and time frames for which SCC is possible. Based upon these results, the potential for SCC to occur in initial and renewal license terms can be determined, the appropriateness of current technical guidance and practices can be assessed, and the need for aging management can be determined.

2. PURPOSE

This R&D Roadmap is focused on acquiring sufficient data to understand the phenomenon of SCC in the context of dry cask storage. The elements within this R&D Roadmap are 1) Failure modes and effects analysis (FMEA); 2) Literature survey; 3) Voluntary inspections; and 4) Degradation models. The goal is to create a Susceptibility Assessment by developing the data sufficient to identify the subsets of in-service SS canisters as a function of time and location that may become susceptible to SCC. This is an important first step that will bring closure to the RIRP. Other actions within the industry's overall approach to addressing this potential issue and leading to an Aging Management Guideline as identified in EPRI's presentation at the December 12, 2012 NRC meeting [EPRI 2012] are outside the scope of this document. This is an initial R&D Roadmap to outline the steps to the Susceptibility Assessment and should be a living document to be updated as items are completed and new information becomes available.

3. BACKGROUND: CORROSION MECHANISMS AND TYPES

There are two, broad classes of corrosion that can affect austenitic SS:

- Atmospheric corrosion – This corrosion class is for conditions where humidity in the air provides the surface moisture to initiate corrosion. The combination of humid air and deliquescent salts[1] can cause local brine pockets on the canister surfaces.
- Aqueous corrosion: The presence of bulk liquid water on the canister surfaces. Corrosive chemical species dissolved in the bulk water phase would be responsible for possible corrosion.

Corrosion types:

- General (uniform);
- Pitting, crevice, and localized;
- Microbially-influenced corrosion (MIC);
- Stress-corrosion cracking (SCC)

General corrosion is the only mode that results in a fairly uniform corrosion rate across the entire exposed surface. It is characterized by the dissolution of metal without physical separation of the anodic and cathodic sites, at least down to the microscopic level. Although general corrosion by constituents of the ambient atmosphere accounts for large amounts of degradation in terms of material loss, it is a slow process and is easily quantified by testing [Cragnolino 2008]. Corrosion of metal and alloys in industry usually occurs under passive conditions [Cragnolino 2008]. Dissolution of the metal and the formation of a passive film at the metal surface reduce corrosion rates by limiting mass transfer of dissolved metal away from the surface.

Localized corrosion, like pitting and crevice corrosion, is characterized by a local breakdown in the passive film in the presence of electrolyte solutions containing Cl^-, other halide ions, such as I^-, and other anions like SO_4^{2-}. Pitting corrosion produces cavities that are usually as deep or deeper, than the cavity diameter. Carbon steel particles embedded in the surface of stainless steel as a result of fabrication and handling can also initiate pitting. Crevice corrosion is different from pitting corrosion in that it occurs where small volumes of water can enter and be held strongly by surface tension, such as crevices formed by metal junctions, valve seats, and joints. The halide ions in the water aggressively attack the exposed metal surface and can increase corrosion rates locally by many orders of magnitude.

Stress corrosion cracking (SCC) occurs in corrosive environments when the metal or alloy is under tensile stress. Cracks in the metal or alloy may propagate slowly to rapidly (from 10^{-12} to 10^{-3} m s^{-1}) under conditions in which general corrosion would otherwise be limited by a passive layer. SCC is of concern because the potential high rates of crack propagation can cause significant damage in a short period of time. SCC is highly dependent upon material type, environmental conditions (dissolved salts, pH, temperature, flow rate), and the source of the

[1] Salts that essentially "pull" moisture out of the air by lowering the water vapor pressure at the solid salt surface such that water in the vapor phase condenses on the salt surface. The relatively large amount of salt and limited water results in concentrated salt brines.

stress. While the initiation of SCC could depend on ambient environmental conditions [Cragnolino 2008], further corrosion and cracking may not be sensitive to such conditions.

Galvanic corrosion results when different metals or alloys are coupled together and one acts as a cathode and the other the anode. An electrolyte solution can serve to transfer electrons from the anodic material to the cathodic material, causing local galvanic corrosion of the anodic material. The rate of this process is especially noticeable when there is a large cathodic area compared to the anodic area. In recognition of this corrosion mechanism, dry storage systems using SS canisters are designed to avoid galvanic corrosion of the canisters.

Of the above corrosion types and mechanisms, atmospheric corrosion leading to SCC is likely the degradation mechanism of primary concern for SS dry storage canisters. Hence, this R&D roadmap focuses on acquiring sufficient data to understand the phenomenon of SCC in the context of dry cask storage.

4. CURRENT STATE OF KNOWLEDGE

The goal of the Susceptibility Assessment is to:

- Identify the conditions required for SS canister corrosion with the primary focus on stress-corrosion cracking (SCC);
- Recommend the combination of models and monitoring systems utilities can use to determine which of their canisters (if any) may become susceptible to SCC and when that may occur.

In achieving these goals, a Susceptibility Assessment will be developed by industry and used to determine if, and where, there may be potential concerns for SCC. Application of the Susceptibility Assessment would provide useful information in the planning of future in-situ inspections and development of guidelines for aging management. It is noted that much of the information needed for the Susceptibility Assessment is unknown at this time, and as such a draft would be premature.

4.1 SCC of SS Dry Storage Canisters: Necessary Conditions

In order for SCC on austenitic stainless steels to occur, all of the following conditions need to be present:

- A metal susceptible to SCC.
  - Austenitic stainless steels such as Grades 304 and 316.
- Sufficiently high tensile stresses in the SS. Typical sources of tensile stresses:
  - Shrinkage in the welds due to thermal contraction as the weld cools to room temperature. Residual stresses in welds are the largest when the welds are rapidly cooled rather than being thermally or mechanically annealed to relieve these tensile stresses ("stress relieved"). SS dry storage canisters currently in use do not have welds that have been stressed relieved. This is true for the canister body longitudinal and circumferential welds and the lid closure welds.
  - Rolling of flat plates into the shape of the canister body.
- Presence of deliquescent salts on the SS surfaces.

- Typical source is airborne salts and other contaminants drawn inside the concrete overpack by natural air convection driven by used fuel decay heat. At present, it is thought that the airborne salt concentrations are highest for ISFSIs located near salt water bodies, although this does not mean SS canisters located away from salt water bodies are not susceptible to SCC as deliquescent salts are also commonly found in inland atmosphere suspended particulates.

- Humidity sufficient to cause deliquescence. The amount of humidity required to cause deliquescence is a function of the:
  - Temperature of the humid air;
  - SS canister surface temperature;
  - Type of salts present on the SS surface;
  - Surface concentration of those salts on the SS
- Temperature
  - Temperature is an important parameter in the potential for CISCC in dry storage canisters. In general, higher temperatures cause higher corrosion rates. However, higher dry storage canister surface temperatures could prevent the deliquescence of salt. Given that higher temperatures lead to both higher corrosion rates (if deliquescent brines are present on the SS) and lower SS surface relative humidity levels (reducing the possibility of deliquescence), there is a range of temperatures over which SCC can occur. Temperatures higher than this range lead to SS surface relative humidity levels too low to form deliquescent brines. Temperatures lower than this range may slow the corrosion rates sufficiently to make SCC unlikely even during extended storage periods.[2]

4.2 SCC of SS Dry Storage Canisters: Limitations in the Current State of Knowledge

While some data are available that can help identify the conditions under which SS dry storage canisters may become susceptible to SCC, there are data gaps.

4.2.1 Limited, Conflicting Experimental Data

While there is a huge amount of R&D available on SS SCC, the majority of it is not applicable to SCC for in-service used fuel dry storage SS canisters. Much of the experimental R&D was conducted using materials or conditions not relevant or expected for in-service dry storage canisters. Some experiments have been conducted that may be relevant.

Of potential relevance are the experiments conducted by CRIEPI [Shirai et al., 2011; Tani et al., 2009] in Japan and ongoing experiments funded by NRC at the Center for Nuclear Waste Regulatory Analyses (CNWRA) at the Southwest Research Institute [Mintz et al., 2010; Mintz et al., 2012]. Additional tests are being planned by the UFDC, as well as at other facilities outside the US.

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[2] However, if the low end of the temperature range is below ambient, then the SS canister may remain more or less permanently susceptible to SCC once the surface temperatures descend below the upper bound temperature – assuming sufficient RH and deliquescent salts.

The results of the tests conducted by CRIEPI and CNWRA are not in full agreement regarding the specific conditions that lead to SCC. Differences are:

- The required salt surface concentration;
- The temperature range under which SCC will occur;
- The relative humidity range.

In some cases, the differences are potentially significant, such as the temperature range of SCC susceptibility. The CRIEPI experiments suggest SCC can occur at temperatures up to ~80°C, whereas the CNWRA experiments suggest that above about 45°C SCC will not occur. For SS dry storage canisters in service, the time at which canister surface temperatures drop below 80°C may be considerably earlier than when they drop below 45°C.

Furthermore, it is not clear whether CRIEPI or CNWRA measured or calculated the residual stresses in the SS material in their tests. Without such information, it will be difficult to assess whether even these tests are applicable to in-service SS dry storage canisters. It is possible that differences in residual stresses in the test specimens used by CRIEPI and CNWRA are contributing to the difference in salt, temperature, and humidity conditions required for SCC.

4.2.2 Unknown SS Dry Storage Canister Residual Stresses

Little to no information is available on the residual stresses on the in-service SS dry storage canisters. Residual stresses were not typically calculated or measured for canisters produced by a particular fabricator. While the cask vendors specify particular welding standards for the fabricators to follow, there are differences in welding procedures between fabricators. In some cases, welding procedures for the same fabricator changed over time.

4.2.3 Amount of Salts and Other Contaminants on the In-Service Canisters

Existing experimental data do clearly show that SCC is more likely for higher salt surface concentrations. However, with the exception of a handful of samples collected from just one canister at Calvert Cliffs, no other surface contaminant information is currently available.

At present, no correlations between salt/contaminant surface concentrations and these variables have been developed for the ISFSI systems used in the US. Hence, it is not possible to determine salt/contaminant surface concentrations without taking actual measurements.

4.2.4 In-Service Canister Surface Temperatures

Almost no direct measurements of the in-service canister surface temperatures are available.

While the spatial and temporal distribution of surface temperatures can be predicted using existing thermal models used by the cask vendors, these thermal models use a set of bounding assumptions that result in overestimates of temperatures. These bounding assumptions are used in the licensing process in order to provide reasonable assurance that the 400°C peak cladding temperature limit is not exceeded during drying. Using these same models will likely result in overestimated canister surface temperatures.

However, in order to determine when SCC may initiate, it is necessary to determine the time at which the canister surface temperature falls below the temperature threshold at which SCC may initiate. For this case, the assumptions the cask vendors made to ensure peak cladding temperatures are not exceeded, will result in non-conservative estimates of the time at which canister surface temperatures drop below a particular temperature.

5. PROPOSED SUSCEPTIBILITY ASSESSMENT R&D

This chapter outlines the R&D needed to develop a Susceptibility Assessment to provide a firm technical basis for industry to determine which in-service canisters may be susceptible to SCC, where they are located, and when they will become susceptible to SCC. The required R&D components are identified in Section 5.1. A brief summary of who has conducted or is conducting the relevant R&D is provided in Section 5.2. Section 5.2 also includes EPRI's recommendations regarding other organizations who should conduct relevant R&D. EPRI outlines a proposed schedule for completion in Section 5.3.

5.1 Susceptibility Assessment R&D Components

This section briefly describes the four elements to produce the Susceptibility Assessment and the research needed to achieve this goal. When interpreting laboratory and field data and modeling results, measurement uncertainties or modeling numerical limitations should be kept in mind.

5.1.1 Failure Modes and Effects Analysis

A Failure Modes and Effects Analysis (FMEA) is needed to systematically identify the credible failure modes that could impact performance of the stainless steel dry storage canisters. For the purpose of this Susceptibility Assessment, the focus is on the SS canister and associated welds/closure mechanisms.

The FMEA needs to identify:

- Failure modes, particularly those associated with SCC and aging-related mechanisms/processes;
- Consequences of the failure modes;
- Any gaps that need to be addressed, and priority for addressing these gaps;
- Technical evaluations to include in the safety assessment.

5.1.2 Literature Survey

There is a huge amount of R&D available on SS SCC, yet much of it is using materials or conditions not relevant or expected for in-service dry storage canisters. A comprehensive literature review of past and current work relevant to the specific concerns related to CISCC of welded stainless steel canisters is needed. Literature applicable to loaded dry storage canisters should consider:

- Indirect exposure to the environment;
- Air movement around the surface;
- Temperature ranges (e.g. time to reach temperatures for deliquescence).

5.1.3 Voluntary Inspections

Inspections of canisters at volunteer sites located in or close to potentially corrosive environments and representing the diversity of storage systems in use would provide information potentially applicable to the majority of SS dry storage canister users.

In general, the inspections should include:

- Visual examination of canister surfaces for signs of pitting and corrosion:
    - Focus on shell welds, areas in contact with other surfaces (if possible);

- Inspect as much of the canister surface as possible, but at least some areas with different air flows, canister surface temperatures, upper and lower surfaces;
- Temperature measurements: both ambient and on the canister surfaces at various locations to gauge the spatial temperature distribution. These data will be used to:
  - Benchmark new thermal models so better predictions can be made of canister surface temperature spatial and temporal distributions;
  - Determine if the in situ observations are consistent with laboratory experiments conducted at similar temperatures;
- Canister surface contaminant measurements (through sample retrieval and analysis)
  - Chemical composition;
  - Surface concentration;
  - Other characteristics (such as whether the material seems tightly bound to the surface or is fluffy such that much of it is not really contacting the surface);
- Monitoring of ambient conditions in the storage area to provide information on the temporal distribution of:
  - Temperature, preferably near the air inlet and right at the air outlet;
  - RH at the same locations;
  - Average concentration of atmospheric salt and other pollutants/organics in the ambient air.

Other field data:

- ISFSI site plan details that may affect local air flow and atmospheric properties (temperature, RH, salt/contaminant/organic content and concentration). This could be important to have confidence that the correlation developed between canister surface contaminant concentrations and the ambient conditions based on field data collected for only a few canisters is applicable to other systems of similar design, age, decay heat, etc. Relevant details may be:
  - ISFSI module orientation;
  - Nearness to other structures – especially w.r.t. how those structures may affect local wind patterns; and
  - Elevation compared to other site, land or water body features that may affect local atmospheric conditions.

EPRI anticipates it will take a minimum of two years to complete three inspections as the lead time to prepare test equipment and the times of year when the required utility staff can support the inspection need to be taken into consideration.

5.1.4 Degradation Models

The following models need to be developed to predict degradation and susceptibility to CISCC:

- Best estimate thermal models using field data for benchmarking;
- Residual weld stress models (if weld residual stress data are not available as discussed in 5.1.4.1);
- SCC crack initiation and propagation models based on a combination of literature data and the laboratory experiments described in Section 5.1.4.2;

- Correlations of canister surface salt/contaminant/organic temporal and spatial compositions and concentrations as a function of:
  - Storage time;
  - Cask system type:
  - Horizontal versus vertical;
  - Air flow patterns affecting deposition rates and locations;
  - Other dimensions;
  - Atmospheric characteristics:
  - Time-averaged contaminant concentrations;
  - Decay heat as a function of time (affects air flow velocity).

EPRI anticipates that once the field inspection data are available, all of these models can be developed in less than a year.

With the above models developed and adequately benchmarked, it will be possible to complete the Susceptibility Assessment and rely on data collected from only the outside of the storage modules.

5.1.4.1 Weld Residual Stress Data

Ideally, residual stress data for the canister shell, welds, heat-affected zones (HAZ) adjacent to the welds, and closure lid manufacturing data would be collected. Examples of the data to be collected:

- Applicable codes and standards;
- Base metal plate rolling processes and surface contamination control;
- Weld procedures used for each canister lot;
- Residual stress measurements from samples produced for each lot (assuming such samples are available).

Progress is being made by participants in EPRI's Extended Storage Collaboration Program (ESCP) to collect samples manufactured using prototypic weld processes. The goal is to be able to provide a consistent set of prototypic samples to those ESCP members who will conduct experiments. This will assist in being able to conduct experiments using relevant materials and to make inter-laboratory comparisons where more than one laboratory is conducting experiments under the same conditions.

5.1.4.2 Laboratory Experiments

A wide variety of data from laboratory experiments conducted under prototypic conditions is needed to support the development of models to predict the initiation and propagation of SCC. Repeatable laboratory experiments by multiple organizations need to be conducted to reduce the uncertainty in the conditions required to cause SCC in the SS materials used in dry storage canisters (base metal and welds).The experimental parameters and possible ranges are summarized in the following tables.

Material	
Property	Example Values/Range
Base Metal SS Type	304
	316
Metal Condition	clean
	cold worked
	embedded carbon
Weld Filler	Alloy 1
	Alloy 2

Weld Properties	
Property	Example Values/Range
Weld Heat Input	T1
	T2
Weld Passes	n1
	n2
Weld Joint Design	WJ1
	WJ2
Weld Surface Profile	HAZ
	grinding
	reinforcement
Weldment	Shell
	Closure
Stress Relief	none
	SR1
	SR2

Contaminants	
Property	Example Values/Range
Surface Deposit Material Composition	Sea Salt
	MgCl2
	NaCl
	Sea Salt + Soil/Clay
Surface Salt Concentration (g/m2)	0.01 - 1

Humidity	
Property	Example Values/Range
RH	0.15 - 0.75

Temperature	
Property	Example Values/Range
Temperature (C)	25 - 80

Given the large number of parameters and test conditions necessary for crack initiation and growth development, a significant number of samples will need to be prepared and experiments conducted. Also, the length of time required for crack initiation (if any) and growth may also be considerable such that the test duration may need to be at least a year. Hence, it is reasonable to assume the amount of time required to complete the laboratory testing will be on the order of three years.

5.2 Organizations to Conduct Research for Susceptibility Assessment

Due to the extent and diversity of the needed research data for the Susceptibility Assessment, multiple organizations will be needed to collect all the necessary data. EPRI is planning to perform the FMEA and literature survey and to conduct the field inspections (with co-funding from DOE and in-kind services from the cask vendors and host utilities). EPRI is assuming other organizations will complete the major portions of the degradation models including relevant experimental work. Some organizations, such as the Central Research Institute of the Electric Power Industry (CRIEPI, Japan) and Center for Nuclear Waste Regulatory Analyses (NRC/CNWRA) have already completed some of the relevant experiments, but additional experiments are needed. EPRI understands DOE's Used Fuel Disposition Campaign (UFDC) is currently performing additional experiments that will be very helpful in compiling the Susceptibility Assessment. DOE-funded Nuclear Energy University Program (NEUP) groups are also planning to conduct experiments and perform literature surveys. In addition, other ESCP participants have indicated their organizations will also undertake additional experiments.

The following is a summary of the organizations EPRI is aware of that are or will be performing work, conducting experiments or field investigations required to complete the Susceptibility Assessment.

Failure Modes and Effects Analysis:

- EPRI (underway)

Literature Survey:

- EPRI (underway)
- NEUP program (MIT – underway)

Field data:

- Completed[3] using EPRI funding and in-kind contributions by TN and Constellation:
    - Calvert Cliffs (red star in Figure 1) visual inspection and surface temperature and sample collection. (NUHOMS® site-specific modules with 24P canister, 16 years in service, located 0.8 km from the Chesapeake Bay);
- Additional inspections EPRI is pursuing (co-funding by EPRI and DOE with in-kind contributions from the cask vendor and the host utility):
    - At least one vertical dry storage system near the coast (see Figure 1);
    - At least one more horizontal or vertical design location with similar characteristics;
    - Optional for now: at least one inland site with storage modules with the same characteristics as one of the systems to be inspected near a salt water body.

DOE has provided co-funding to EPRI to conduct the next two inspections following the initial inspection at Calvert Cliffs. At present, EPRI is negotiating with Hope Creek (orange star in Figure 1) and Diablo Canyon to host field inspections. In-kind resource contributions to the field inspections are essential from the host utilities and the relevant cask vendor.

All sites hosting inspections should collect atmospheric data and air inlet/outlet temperature/RH data. EPRI will work with the host utility to determine if additional atmospheric monitoring equipment is necessary beyond that which the utility already may have in place. If needed, EPRI and possibly a third party will provide the atmospheric monitoring equipment. EPRI and/or third parties will arrange for chemical analyses of the atmospheric samples collected.

Model development:

- Thermal models:
    - Ongoing or completed:
        - PNNL completed and benchmarked a model against casks in long-term storage at INL. PNNL has completed the thermal model for the

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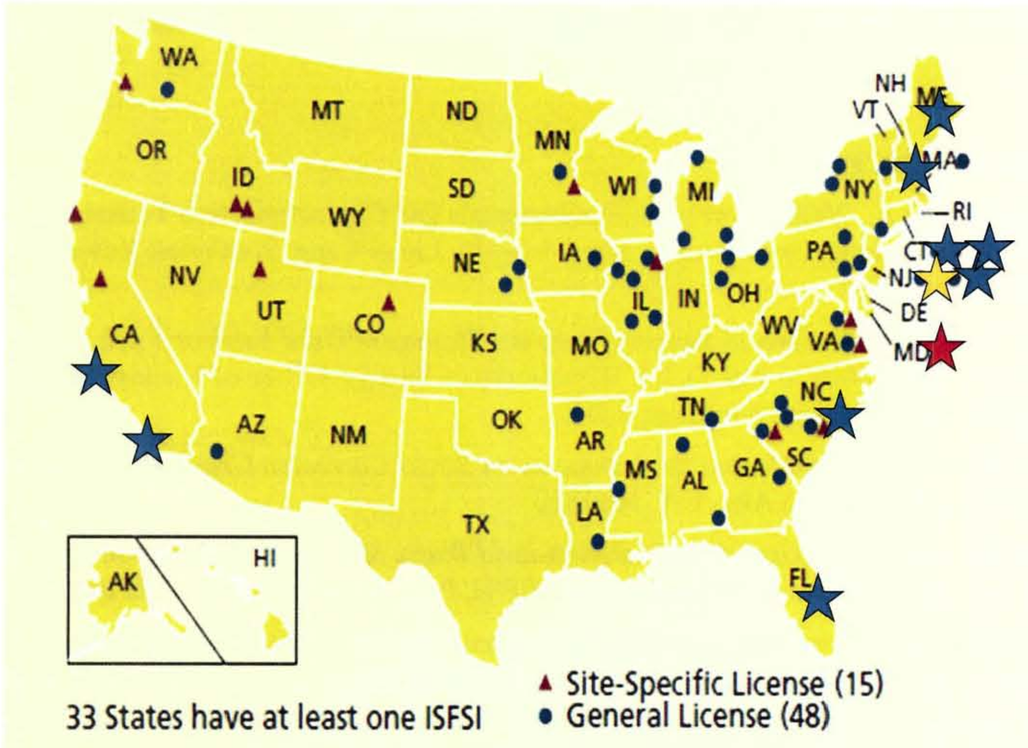
[3] EPRI is unaware of any other inspections completed on in-service dry storage systems using SS canisters.

    Calvert Cliffs canisters. PNNL has also offered to provide additional models to support future inspections.

- Others in the future:
  - Cask vendors;
  - DOE UFDC;
  - Other countries with their own designs using welded SS canisters.

- Residual stress models:
  - EPRI will develop residual weld stress models as part of, and in context with the FMEA;
  - EPRI is aware of at least one cask vendor who performs these models;
  - All cask vendors should develop these models for their systems in service.
- SCC crack initiation and propagation models:
  - EPRI will perform these modeling efforts as part of the FMEA.
  - DOE UFDC (EPRI expects UFDC to develop these models)
  - NRC (EPRI is aware NRC is already preparing a draft report on this issue)
- Correlations to predict canister surface salt/contaminant/organic material compositions and concentrations as a function of time and surface position:
  - CRIEPI has developed a correlation for its particular storage system, although it does not appear to be directly relevant to the ISFSIs in use in the US;
  - EPRI will develop correlations as the data become available;
  - At least one other organization should develop correlations as a check on the correlations EPRI produces, and possibly the correlation developed by CRIEPI (possibly DOE UFDC or NEUP).
- Laboratory experiments:
  - Completed or underway:
    - CRIEPI (completed);
    - CNWRA (underway)
  - Additional organizations who should conduct additional experiments:
    - As a minimum, DOE UFDC;
    - NEUP programs;
    - It would be ideal if at least one other organization outside the US conducted some of these experiments. EPRI is aware of the following who have expressed some interest:
      - KAERI (Korea);
      - IAEA via contractors;
      - ENRESA (Spain)

Figure 1. Target Locations for SS Dry Storage Canister Inspections



5.3 Proposed Schedule for Completion of Susceptibility Assessment

EPRI proposes the following schedule for completion of the Susceptibility Assessment:

By end of 2013:

- EPRI completes FMEA
- EPRI and NEUP complete literature survey
- A total of three field inspections completed
- Prototypic canister materials are obtained for subsequent laboratory and residual stress analyses.

By end of 2014:

- CNWRA completes Year 1 of its laboratory studies using prototypic canister materials and stress conditions.
- EPRI completes residual stress model
- EPRI completes crack growth model
- UFDC completes Year 1 of its laboratory studies.
- One other laboratory outside the US may complete some laboratory studies.
- All three vendors complete best estimate thermal models.
- EPRI completes its correlations between atmospheric data and the amount of material deposited on the SS canister surfaces.

By the middle of 2015:

- EPRI completes its initial Susceptibility Assessment

The initial Susceptibility Assessment may be revised based upon additional laboratory or field data.

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