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September 9, 2014

MEMORANDUM TO: Anthony Hsia, Deputy Director
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

FROM: Kristina L. Banovac, Project Manager /RA/
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

SUBJECT: SUMMARY OF AUGUST 5, 2014, PUBLIC MEETING WITH THE NUCLEAR ENERGY INSTITUTE ON CHLORIDE INDUCED STRESS CORROSION CRACKING REGULATORY ISSUE RESOLUTION PROTOCOL

Background

The U.S. Nuclear Regulatory Commission (NRC) staff held a public meeting with the Nuclear Energy Institute (NEI), their members, and consultants on August 5, 2014, to discuss topics associated with the chloride induced stress corrosion cracking (CISCC) Regulatory Issue Resolution Protocol (RIRP), including aging management, flaw growth, and flaw tolerance.

The meeting was noticed on July 24, 2014 (ML14206A735). The meeting attendance list is provided in Enclosure 1.

Discussion

The meeting discussion generally followed the meeting agenda, which is included in Enclosure 2. Enclosure 3 contains the presentations given by the NRC and NEI as meeting handouts.

NEI provided an update of the schedule and remaining tasks of the RIRP resolution plan, as reflected in their February 7, 2014 letter (ML14052A015). The RIRP will be closed after agreed-upon susceptibility criteria are developed. The Electric Power Research Institute's (EPRI's) current work on flaw growth and flaw tolerance is another step towards developing the susceptibility criteria.

Industry representatives provided an overview of EPRI's Flaw Growth and Flaw Tolerance Assessment for Dry Cask Storage Canisters. EPRI mentioned that the future report on susceptibility criteria will describe different actions that may be taken and how that will impact risk, but it will not specify at what point mitigation measures are needed. The licensees' corrective action programs will need to evaluate and determine what mitigation measures are needed and when. NRC staff mentioned that it would like to see some discussion and explanation in the report on any actions that can be taken to prevent CISCC. Industry representatives presented a summary of the literature and data used to develop the crack growth rate model, details on the crack growth rate methodology, and the flaw tolerance assessment.

NRC staff mentioned that current data indicates that a crevice environment (e.g., where a canister meets the support rails in a horizontal storage system, or deposits such as a wasp nest on a side of a canister in a vertical system) may promote stress corrosion cracking, and the staff inquired how industry will consider this in its work. Industry representatives mentioned that this was not an area it was specifically planning to explore in the CISCC RIRP. However, NEI took an action to consider the addition of this work to consider crevice effects and whether it needed to be added to the scope of work or as a specific deliverable for the CISCC RIRP. NEI will also consider whether this work could be done within the current schedule for the RIRP resolution plan or whether any adjustments to the schedule are needed.

NRC staff questioned the conclusions that crack growth rate is generally not dependent on the stress intensity (K) value, given the limited data set. Industry noted that they compensated for the limited data by taking a conservative statistical approach to derive conservative values for the crack growth rate coefficients and modeling the crack growth rate.

NRC staff noted that we would like to see some discussion in the susceptibility report on prioritization of inspection/examination, based on the various stainless steel alloys that may be more susceptible to CISCC. Industry representatives mentioned that they are planning to look at this in the work on initiation of cracking, and this will be an important part of the susceptibility assessment and criteria. EPRI representatives also noted that the EPRI report: Literature Review of Environmental Conditions and Chloride-Induced Degradation Relevant to Stainless Steel Canisters in Dry Cask Storage Systems (EPRI-3002002528, May 2014) does discuss this, but they will make sure it also gets discussed in the susceptibility criteria report.

NRC staff noted that the susceptibility criteria report should also discuss the weld heat affected zone and how this impacts CISCC susceptibility. An industry representative also mentioned that the report should discuss how multiple or combined susceptibility factors (e.g., intersection of the weld heat affected zone at a crevice location, like a canister and support rail intersection) would affect overall susceptibility. EPRI noted they will address this in the susceptibility report.

There were some questions on the flaw tolerance assessment regarding the calculation of the critical flaw size for structural tolerance of the system (for consideration of what would structurally challenge the system to the point where it should not be moved), as the critical flaw sizes were very large. Industry representatives clarified that the critical flaw size was calculated only for the purposes of obtaining information on the size of the flaw that could lead to structural concerns if there was a need to move the system. There is no intent for allowing a flaw to get to this size, or any expectation that this flaw size would be used as an acceptance criterion for the point where mitigation measures would be needed. NRC staff noted that it appreciated the clarification, but acceptance criteria will need to be developed for determination of when mitigation actions are needed.

NRC staff questioned whether the assessment of helium depressurization and air ingress in the flaw tolerance assessment considered oxidation of components in the canister. Industry representatives noted that the flaw tolerance assessment did not look at this, but the Failure Modes and Effects Analysis (FMEA) of Welded Stainless Steel Canisters for Dry Cask Storage Systems (EPRI-3002000815, December 2013) does discuss oxidation of fuel cladding and the effects.

NRC staff and industry representatives agreed that a through-wall crack would not be acceptable, and industry representatives noted that they are not planning to make a risk argument for the acceptability of a through-wall crack.

NRC staff questioned whether EPRI considered the number of flaws on a canister. Industry representatives noted that they may consider this in their future probabilistic assessment to look at the surface area to crack ratio to see how many flaws could occur in a certain area on a canister. However, they found that depressurization occurs somewhat quickly (on the time scale of extended storage), so multiple cracks may not really be an issue for maintaining a helium environment inside the canister.

NRC staff questioned whether EPRI's work will include guidance on how to select a canister at a site for inspection based on various considerations, like the way fabrication was done (e.g., if there were any repairs, if there were any temporary structures welded to the canister during the fabrication, etc.). Industry representatives noted that they will consider fabrication practices and repairs.

NRC staff had some questions on the calculation of the crack growth rate parameters. Industry representatives noted there were errors on slide 22 of the EPRI presentation. Following the meeting, industry representatives provided the corrected slide, which is included in the attached EPRI presentation.

The NRC presented a summary of NRC-sponsored CISCC testing. In response to an industry question, the NRC clarified that there was cracking observed in the as-received (not sensitized) material at 0.1 g/m^2 salt concentrations in the U-bend tests (included in NUREG/CR-7170, "Assessment of Stress Corrosion Cracking Susceptibility for Austenitic Stainless Steels Exposed to Atmospheric Chloride and Non-Chloride Salts," ML14051A147). NRC staff also clarified that pits were observed on the specimen surface and the pits were surrounded by the presence of corrosion products on the U-Bend and C-ring specimen surfaces. Stress corrosion cracks were observed to originate from the pits on the specimen surface; however, the time from the observance of pitting to the initiation of the crack was not recorded.

There was a question on whether there was any planned industry work to measure atmospheric chloride concentrations at the sites listed on slide 9, which included power plant operating experience with SCC of stainless steels. Industry representatives noted that there is no planned work to do so, although the EPRI susceptibility report will discuss how to measure atmospheric chloride concentrations for sites to be able to use the susceptibility criteria. The NRC noted that if the atmospheric chloride concentration is to be used by industry to determine susceptibility, then adequate data will be needed to account for seasonal changes.

NRC staff also presented an example aging management program (AMP) for CISCC. In its presentation, NRC staff clarified that the proposed timing of inspections in the CISCC example AMP (i.e., within 25 years of initial loading) provides for a 5-year period from the end of the initial storage period for industry to develop a qualified inspection method. However, once a qualified method exists, the expectation is that the first inspection for CISCC would occur around 20 years (i.e., at the beginning of the period or extended operation). The NRC clarified that based on information obtained in lead system inspections where the composition of atmospheric deposits were characterized, NRC staff independently estimated the time necessary to accumulate a sufficient concentration of chloride containing salts on the canisters surfaces necessary to initiate stress corrosion cracking was at least 30 years. It was noted that a similar conservative estimate on the time necessary to accumulate a sufficient surface chloride concentration was provided by a licensee. NRC staff also clarified that the proposed inspection frequency of every 5 years is based on the estimated crack growth rates from reactor operating experience with CISCC of stainless steels. Based on estimated crack growth rates as a function of temperature and assuming the conditions necessary for stress corrosion cracking continue to be present, the shortest time that a crack could propagate and go through-wall was determined to be 16 years after crack initiation. A 5-year inspection frequency would result in at least 2 inspections that would provide an opportunity to find indications of degradation and allow corrective actions to be implemented to prevent localized corrosion or stress corrosion cracking penetration of the canister.

An industry representative noted that NRC's example AMP on CISCC needs to be clear in its discussion of preventative actions (AMP element 2) that this includes information on whether anything has been done in the past that may be considered a preventative action, and not future preventative actions expected from renewal applicants.

In response to industry questions on development of a qualified inspection method, NRC staff clarified that at this time, the inspection needs to be able to detect SCC. However, if cracking is found, industry needs to be prepared to size and characterize the cracking. NEI mentioned that if cracking was found, licensees would assess and determine what actions were needed through their corrective action programs. NEI's planned aging management guidance in NEI 14-03 (Operations-Based Aging Management for Dry Cask Storage) will discuss how the licensee's assessment should consider the susceptibility criteria. NRC encouraged industry to begin work on development of volumetric methods now rather than waiting until a crack is found, and noted that industry could develop topical reports in this area to obtain NRC's review.

After NRC's presentation, members of the public were given the opportunity to make comments or ask questions of the NRC staff.

One public member noted that the NRC should initiate a rulemaking to prohibit construction of new reactors in locations considered susceptible for CISCC. Also, as the quality of vendors varies, NRC should evaluate individual vendor's fabrication practices. He also noted that modeling work should not be postponed for storage periods beyond 60 years. NRC staff noted that it is focused on preventing through-wall cracks, and that industry can respond to SCC operating experience with the proposal and use of better materials. NRC staff also noted that the NRC does inspect vendors, their fabrication practices, and their quality assurance programs. NRC staff noted that one of the reasons it's shifting to an operations-focused approach to aging management is so that AMPs can be used to manage aging effects into the future (including periods beyond 60 years).

Another public member asked whether the NRC is also looking at carbides in grain boundaries, in addition to looking at atmospheric chlorides. NRC staff responded that it is looking at this and the sensitization of materials. The public member made a detrimental comment about the behavior/conduct of welders. The NRC noted that welders need to be qualified, and the NRC looks at welder and personnel training and qualifications during vendor inspections. The public member questioned whether there were other chemicals in water that could impact the dry cask storage systems, and NRC staff noted that it did look at other atmospheric deposits besides chlorides in NUREG/CR-7170.

Another public member noted that the NRC should look at radiological degradation of canisters. NRC staff mentioned that we do assess neutron exposure and the effects of the exposure on the mechanical properties of the canister materials. There have not been any potential issues identified regarding materials degradation due to radiation in the period of extended operation, but the staff does look at and continues research in this area. The commenter noted that a 2 meter crack (critical flaw size) did not take into account accidents that could happen during transportation. The NRC noted that industry's calculation of critical flaw size was not intended to be used or considered for storage or transportation licensing and certification. The commenter noted that timing of inspections and inspection frequency in the example SCC AMP was confusing, and questioned why the NRC would allow the first inspection to be conducted at 25 years, if it may only take 16 years for a crack to go through-wall. The NRC responded that the calculated time for the crack to go through-wall does not include the time for cooling to the point where deliquescence of the deposited salts could occur on the canister surface or the time for initiation of cracking. The commenter questioned the NRC's reasoning for the recommended sample size of at least one canister at each site. The NRC noted that this is consistent with the NRC's current expectations for the lead system inspection. The expectation is that the licensee would inspect the canister that is most likely to have corrosion or cracking. If any corrosion or cracking was identified, supplemental inspections would be conducted to determine the extent of condition.

Another public member noted agreement with the example SCC AMP that canisters that do not meet the prescribed evaluation criteria must be repaired or removed from service. The NRC noted that licensees have contingency plans in case of fabrication or loading issues, which include unloading procedures and a reflood analysis in case the licensee needs to remove the fuel after loading and drying a canister.

Another public member noted terrorism is a real threat. He noted that inspection of one canister at a site is not sufficient, as there may be hundreds of canisters eventually stored at an ISFSI site. The NRC repeated the earlier discussion that the licensee would be expected to select and inspect the canister that is most likely to have corrosion or cracking for this first inspection. If any corrosion or cracking was identified, supplemental inspections would be conducted to determine the extent of condition. The commenter questioned how a licensee would be able to unload a canister if it needed to be removed from service, if it decommissions its spent fuel pool. The NRC staff noted that there is a requirement in 10 CFR 72.218 for a licensee's 10 CFR 50.54(bb) spent fuel management plan to include a plan for removal of the spent fuel stored under the Part 72 general license from the reactor site. The plan must show how the spent fuel will be managed before starting to decommission systems and components needed for moving, unloading, and shipping this spent fuel.

Another public member noted that it wasn't clear when CISCC could initiate. The NRC noted that it is difficult to calculate a generic minimum time to crack initiation, as there are several site-specific factors that need to be considered in such a calculation (e.g., atmospheric chloride concentrations, atmospheric and environmental conditions, the time for the canister to cool to the point where salts can deliquesce, which depends on the specific loading of the canister and the decay heat, the amount of chlorides deposited on the canister, etc.). The commenter asked for a rough time range, and the NRC responded that a rough estimate (assuming favorable conditions for cracking per the factors above) would be 30 years to initiate a crack. The commenter repeated the earlier concern regarding decommissioning of the spent fuel pool if it is needed in the future to unload a canister that needs to be removed from service. NRC staff mentioned that there is a separate effort at the NRC to consider cask unloading capability, as this issue was raised in the Petition for Rulemaking submitted by C-10 Research and Education Foundation, Inc. (PRM-72-6). The staff is still considering the petitioner request to require a safe and secure hot cell transfer station coupled with an auxiliary pool to be built as part of an upgraded ISFSI design certification and licensing process.

TAC No.: LA0233

Enclosures:
1. Meeting Attendees
2. Agenda
3. Handouts
   - EPRI Flaw Growth and Flaw Tolerance Assessment for Dry Cask Storage Canisters (EPRI)
   - Chloride-Induced Stress Corrosion Cracking Tests and Example Aging Management Program (NRC)

safe and secure hot cell transfer station coupled with an auxiliary pool to be built as part of an upgraded ISFSI design certification and licensing process.

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Chloride-Induced Stress Corrosion Cracking Tests and Example Aging Management Program (NRC)

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Agenda

Public Meeting with Nuclear Energy Institute on Chloride Induced Stress Corrosion Cracking Regulatory Issue Resolution Protocol

August 5, 2014
8:30 AM – 12:00 PM

8:30 – 8:40 AM	Welcome, Introductions, and Meeting Objectives (All)
8:40 – 8:55 AM	Update of RIRP Schedule/Tasks (NEI)
8:55 – 9:10 AM	Overview of Flaw Growth and Tolerance Report (Electric Power Research Institute)
9:10 – 10:25 AM	Literature Review – Flaw Growth and Tolerance Methodology (Dominion Engineering, Inc.)
10:25 – 10:40 AM	**Break**
10:40 – 11:20 AM	Overview of Aging Management Program for Stress Corrosion Cracking (NRC)
11:20 – 11:35 AM	Discuss Next Milestones and Anticipated Dates (All)
11:35 AM – 12:00 PM	Public Comments and Wrap Up

PRESENTATION HANDOUTS

Enclosure 3