From:	Cook, William
To:	Gray, Mel; Bower, Fred; Barkley, Richard
Subject:	FW: NextEra Response to NRC 12/23/15 Request for Additional Information for ASR/CEB and RHR Vault
Date:	Friday, February 26, 2016 7:49:03 AM
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Received this morning.

From: Ossing, Michael [mailto:Michael.Ossing@nexteraenergy.com]
Sent: Friday, February 26, 2016 7:29 AM
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Subject: [External_Sender] NextEra Response to NRC 12/23/15 Request for Additional Information for ASR/CEB and RHR Vault

Bill

Attached is the word document and pdf version of the NextEra response to the NRC request for additional information pertaining to Operability Determinations for ASR affected Containment Enclosure Building and the RHR Vault documented in NRC letter dated December 23, 2015.

Michael Ossing
Licensing Manager
Seabrook Station

Reference: Summary of Telephone Conference Call Held on December 22, 2015, Between the NRC and NextEra Concerning a Request for Additional Information Pertaining to Seabrook Station Operability Determinations for the Alkali Silica Reaction (ASR)-Affected Containment Enclosure Building and the Residual Heat Removal Equipment Vault, December 23, 2015 (ML15357A326)

NextEra Energy Seabrook, LLC (NextEra) submits the below in response to the questions and information requested in Enclosure 2 of the referenced document.

Containment Enclosure Building (CEB) Local Deformation – Root Cause Evaluation (CR 2014325) Review - Questions

1) What is the role of the Finite Element Analysis (FEA) with respect to a CEB structural analysis (FP 100985) and its applicability to an update/revision to the open Prompt Operability Determination (POD) for the CEB (AR 01664399)?

Response:
The role of the Exploratory Finite Element Analysis (FEA) (FP100939) was to identify plausible loads causing the observed CEB deformations by simulating the deformed shape of the CEB. The results of the FEA determined that the deformations were primarily caused by internal ASR expansion of the CEB and ASR expansion of the concrete backfill.

FP 100985 is a finite element structural analysis and design confirmation of the as-deformed condition of the CEB. The analysis included all current licensing basis (CLB) loading combination including the effects of ASR expansion. A Prompt Operability Determination (POD) under AR 2094762 was completed that assessed the structural integrity of the CEB based on the results of the analysis documented in FP 100985

2) If used in support of an update/revision to the POD, provide a comprehensive description of the FEA, with applicable inputs, assumptions and outputs, to the NRC staff for review.

Response:
FP 100985 has been made available to the NRC through CERTREC. Description, Assumptions, and Results of the FEA are provided in Sections 5, 6, and 7. Section 5 provides a description and justification of assumptions used in the analysis. Section 6 includes a description of the structure, modeling, and analysis. Section 7 includes the design confirmation per ACI 318-71.

3) The following are specific FEA review issues/questions of interest to the NRC staff include:

FP 100939 used a simplified FEA to simulate the deformation. FP 100985 used a more detailed FEA model to simulate the deformation, measured strains, and stresses attributed to the deformed condition.

a. What variable or input to the FEA was used to mimic ASR expansion (reference p. 12);

Response:
In the FP 100985 model, the section of the CEB that is susceptible to ASR expansion is modeled using a combination of elements representing concrete and reinforcement. Hoop (horizontal) and meridional (vertical) steel membrane elements representing the reinforcement steel are overlaid on the concrete plate elements within the model. ASR expansion of reinforced concrete members are shown to cause compression in concrete and tension in reinforcements as reported in “Structural Effects of Alkali-Silica Reaction”,

Institution of Structural Engineers (July 1992), and "Critical Review of the Structural Implications of the Alkali Silica Reaction in Concrete", Transportation and Road research Laboratory Report 169 by LA Clark (1989). To achieve this stress distribution while maintaining equilibrium, SGH simulated ASR expansion of the CEB walls by applying thermal expansion to concrete elements. This method of applying expansion results in tensile stress in the reinforcement and compressive stress in the concrete corresponding to the as-deformed condition while maintaining structural equilibrium.

A lower-bound and upper-bound expansion of 0.03% and 0.06%, respectively, are applied to the below-grade concrete elements.

b. What variable or input to the FEA was used to mimic backfill ASR expansion and what load values were used/assumed and the basis for those values (reference p. 15);

Response:
Backfill expansion is simulated as a radial inward pressure acting on the CEB wall at elevation 0 and below.

The applied load corresponds to the vertical pressure acting on the backfill for an upper- and lower-bound case. The upper-bound pressure corresponds to the total weight. ASR expansion occurs in the direction with least resistance; therefore the vertical pressure serves as an upper limit. Once this pressure is reached, additional backfill expansion occurs in the vertical direction.
The lower-bound pressure was taken as one half of this value. Simulation of the lower-bound pressure in the model resulted in deformation of the structure that aligned more closely with the observed condition in the field.

c. An ASR-attributed expansion value of between 0.03 and 0.14% was used to represent the circumferential growth and associated deformation in the FEA. What is the rationale for applying this block/wall design expansion value to a cylindrical design model? And, what conservatisms or uncertainties are introduced as a result? (p. 14);

Response:
Circumferential and vertical (in-plane directions) strains of 0.03% and 0.06% for the lower- and upper-bound cases were used in the analysis for the design confirmation (FP100985). Expansion of 0.03% corresponds to the average strain measured based on the 15 Crack Index locations measured in 2011 in the CEB. The 0.14% upper-bound value was not used as it significantly overestimates the observed conditions of the deformed shape and strains measured.

The upper-bound expansion of 0.06% is conservatively taken as twice the lower-bound value, which corresponds to the average strain measured in the field. Uncertainties are minimized by relying on observed conditions of the deformed shape and strains measured.

d. How was the FEA model developed and validated? How was it derived and/or compared to the original UE&C design/construction model and the 2012 CEB FEA model used to inform POD AR 01664399?

Response:
The FEA model in FP 100985 is based on the original structural design drawings and was independently reviewed. The dimensions and properties used in the model correspond directly with that which was used in the original design/construction model. Validation of the model included a confirmation of the original structural design (Appendix J of FP 100985).

The geometry of the FEA model in FP 100985 is based on the 2012 CEB FEA model with enhancements to refine the geometry in the area of maximum deformations around the West Pipe Chase opening.

Validation of the model was performed by recreating the as-deformed shape of the CEB with actual loads applied to structure. Loads applied to structure included unfactored design loads (self-weight, hydrostatic pressure, and static soil pressure) and self-straining loads (ASR expansion, creep, shrinkage, and swelling)

4) What is the basis for the conclusion that CEB bulk expansion, and associated deformation has plateaued (p.38)? Absent conclusive evidence, what monitoring is planned or in place to validate this conclusion and provide assurance that further deformation does not compromise CEB structural performance?

Response:
The conclusion that bulk expansion has plateaued is based on the lack of progression in Crack Index (CI) measurements taken at the 40 Tier 3 ASR monitoring locations on a 6 month frequency for a period of 3 years. However, the field measurements will be continued and results will be evaluated as an ongoing process.

Monitoring of expansion and associated deformations will continue per the Structural Monitoring Program (SMP) to confirm the CEB structural performance. The SMP has been updated to include measuring seismic isolation gaps between structures, perform plant walkdowns for deformation of structures and structural components, and perform walkdowns for misalignment of plant components that span between adjacent structures.

5) What is the significance of the FEA model output identifying that the deformation values at +22 foot – azimuth 210 and +119 foot (Springline) are not consistent with actual field measurements (p.15)? What additional actions and/or field measurements does NextEra have planned in order to address this apparent disparity?

Response:
The significance of the deviation between FEA output and field measurements at the above locations is to be determined. Resolution includes addressing the items below.

- At elevation +22 ft. azimuth 210°, the deviation is related to potential deformation in the adjacent CEVA structure relative to the CEB. Supplemental measurements of seismic gaps between the CEB and CEVA structure and potential analysis for displacement of the CEVA Structure is needed to provide a more thorough comparison with FEA output.
- At elevation +119 ft. (Springline), the deviation is potentially related to insufficient measurement data. Further field measurement of the annular gap between Containment and the CEB at the springline elevation will be taken.

6) How will the results of the FEA be used to update the CEB POD, beyond the assessment of the seismic gaps? Specifically, has the CEB deformation and the assumed backfill ASR expansion (and associated loading) added any additional loads on the ASR-affected structures that potentially undermine the current POD margins analyses?

Response:
Structural demand-to-capacity ratios reported in FP 100985 will be used to update the margins in the POD for the CEB. Loads attributed to CEB deformation including ASR expansion of the backfill are included in FP 100985. Potential changes in margins are addressed in section 7 of FP 100985 and the POD completed for AR 2094762.

7) Based upon NextEra's proposed methodology for bulk expansion and deformation monitoring, what acceptance criteria, thresholds, or triggers will be established to prompt follow-up corrective actions or further structural evaluations?

Response:
Additional studies to address further expansion will be performed to establish criteria to prompt follow-up corrective actions. Programmatic requirements will include field monitoring of seismic gaps, expansion measurements, and data gathering of misaligned plant equipment (PEG-098). Development of criteria to prompt follow-up corrective actions or further structural evaluations will be completed in June 2016.

8) The current PODs for ASR-affected structures highlight that ASR is a localized phenomenon. How does the FEA modeling assumption of uniformly applied ASR expansion across various elevations and assumed expansion rates impact the validity of the FEA and the validity of the current margins-based PODs for all ASR-affected structures?

Response:
The total expansion can be replicated either by applying uniform average expansion or locally varying levels of expansion. The uniform ASR expansion applied to the model is based on the average measured expansion at 15 monitoring locations around the CEB. Reviewing the Crack Index measurement data at 15 locations around the circumference shows small variation in expansion. Therefore, application of uniform expansion is justified for the CEB.

Validity of the current margin-based PODs for all ASR–affected structures is not impacted. The margin-based PODs conservatively applied a reduced capacity for ASR-affected concrete. There was no deformation or uniform expansion observed in the other structures similar to that observed in the CEB, hence an analysis for building deformation was not warranted.

9) What physical evidence supports your conclusion that the CEB deformation is attributable to ASR? This question relates to question 8) above. To date, we understand that only four cores have been removed from the CEB and there are a limited number of CCI locations being used for ASR monitoring. Absence a broader sampling of cores and petrographic exams, what confidence does NextEra staff have that the bulk expansion and associated deformations observed are appropriately associated with ASR, albeit a localized phenomenon?

Response:
As part of the Root Cause Evaluation (RCE), the cause/effect diagram identified 16 potential mechanisms that could lead to the observed deformations. Of the 16 potential mechanisms, 12 were determined to not be contributors to the observed deformation as documented in Attachment B of the RCE. The remaining 4 mechanisms: ASR expansion of CEB, ASR expansion of concrete fill, creep, and water swelling, were determined to be contributors and are included in the structural analysis contained in FP 100985. Internal ASR expansion of the structure is based on field measurements while creep, water swelling, and ASR expansion of the backfill are based on industry literature. Considering that the deformations predicted by the analysis correlate well with field measurements and strains predicted by the analysis correlate well with crack index measurements in the CEB, there is a high level of confidence that the observed CEB deformations are attributed primarily to ASR expansion of the CEB and backfill as predicted analytically.

10) Does NextEra plan to update the docketed Integrated ASR Corrective Action Plan with the results of the CEB RCE?

Response:
NextEra does not plan to update the docketed Corrective Action Plan to address its CEB root cause evaluation. The NRC has performed a sample PI&R inspection of the CEB root cause evaluation. The root cause evaluation contains the corrective actions to address the issues associated with the CEB. Some of the actions in the CEB root cause include:

- Performing detailed walk downs to identify the extent of condition
- Updating the structures monitoring program to include activities to monitor conditions going forward
- Performing Finite Element Analyses of susceptible structures
- Updating the UFSAR to address CEB issues

The NextEra actions contained in the CEB root cause-remain available for NRC review.

11) Is there (or are there plans to develop) an assessment of impact of global deformation in terms of rebar stress, including pre-stress, to understand the impact of this structural attribute on the current licensing basis (CLB) limits?

Response:
FP 100985 provides a structural analysis and evaluation of the structure that includes reinforcement stresses due to global deformation and impact on the design code of record. In the FEA model, a combination of elements representing concrete and reinforcement are used wherever expansion is applied. The applied expansion results in tensile stress in the reinforcement and compressive stress in the concrete corresponding to the as-deformed condition while maintaining structural equilibrium.

RHR Vault Operability Update - Questions

1) FP100903, Condition Assessment of Cracking in the RHR and CS Equipment Vault, identifies ASR as the probable cause for the structural cracking and observed deformations. FP 100903, Section 5.2, refers to UE&C design calculation set No. PB-30 with respect to a limited structural analysis. Does NextEra plan to update/revise the current RHR Vault POD based upon the insights provided by FP100903?

Response:
The condition assessment contained in FP 100903 was performed in accordance with ACI 349.3R "Evaluation of Existing Nuclear Safety Related Concrete Structures". Conclusions in the assessment attribute the concrete cracking to internal strain expanding primarily in the vertical direction and not load induced due to external forces. The conclusions were based on the size and pattern of cracking observed in the concrete, specific concrete and steel reinforcing details of RHR Equipment Vaults, and the presence of moisture / efflorescence. As noted in the assessment, the expansion mechanism (i.e. ASR, DEF, swelling) along with the cumulative amount of expansion are items that require validation via field monitoring and material testing of concrete cores removed from the vaults.

NextEra completed a Prompt Operability Determination (POD) under AR 1977456 that assessed the structural integrity of the RHR Equipment Vaults based on the on the insights provided in FP 100903.

2) If revising the RHR Vault POD, provide the supporting structural analysis for NRC staff review. Include the specific modeling assumptions and associated calculations for the interior through-wall crack (discontinuity) at the minus 26-foot elevation.

Response:
The RHR Equipment Vault POD for AR 1977456 has been made available to the NRC through CERTREC. There were no modeling assumptions or associated calculations that addressed the interior through-wall crack (discontinuity) at the minus 26-foot elevation. The through-wall crack at the minus 26-foot elevation is a construction joint in the concrete that was incorporated and evaluated as part of the original design of the RHR Equipment Vaults.

3) Please provide an update on the progress of NextEra's corrective actions and associated monitoring efforts for the RHR Vault.

Response:
Corrective actions and associated monitoring provided below:

ACTIVITY	**STATUS**
Perform baseline condition assessment of concrete	Complete (12/30/2014)
Approve condition assessment report (FP 100903)	Complete (3/17/15)
Complete follow-up inspection/assessment of concrete	Complete (12/30/2015)
Approve follow-up inspection report	Complete (2/9/2016)
Issue EC for installation of monitoring devices and concrete	Complete (1/7/2016)
Complete POD for RHR Equipment Vault concrete	Complete (2/12/2016)
Install monitoring devices and complete concrete core removal	Due 3/30/2016
Provide initial monitoring/test data to WJE	Due 5/15/2016
Approve final condition assessment of Equipment vault concrete	Due 6/15/2016