UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 11, 2017

Mr. Mano Nazar
President and Chief Nuclear Officer
Nuclear Division
NextEra Energy Seabrook, LLC
Mail Stop: EX/JB
700 Universe Blvd.
Juno Beach, FL 33408

SUBJECT: SEABROOK STATION, UNIT NO. 1 – REQUEST FOR ADDITIONAL INFORMATION REGARDING LICENSE AMENDMENT REQUEST RELATED TO ALKALI-SILICA REACTION (CAC NO. MF8260; EPID L-2016-LLA-0007)

Dear Mr. Nazar:

By letter dated August 1, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16216A240), as supplemented by letter dated September 30, 2016 (ADAMS Accession No. ML16279A048), NextEra Energy Seabrook, LLC (NextEra) submitted a license amendment request to revise the current licensing basis for Seabrook Station, Unit No. 1 (Seabrook), to adopt a methodology for the analysis of seismic Category I structures with concrete affected by alkali-silica reaction. The proposed amendment would revise the Seabrook Updated Final Safety Analysis Report to include new methods for analyzing seismic Category I structures affected by alkali-silica reaction.

The U.S. Nuclear Regulatory Commission staff has determined that additional information is necessary to complete its review. A request for additional information is enclosed. Based on a call with your staff on October 6, 2017, NextEra has agreed to provide answers to the request for additional information within 60 days from the date of this letter.

Sincerely,

Justin C. Poole, Project Manager
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-443

Enclosure:
Request for Additional Information

cc w/enclosure: Distribution via Listserv

REQUEST FOR ADDITIONAL INFORMATION

LICENSE AMENDMENT REQUEST REGARDING ALKALI-SILICA REACTION

NEXTERA ENERGY SEABROOK, LLC

SEABROOK STATION, UNIT NO. 1

DOCKET NO. 50-443

References

1. Letter SBK-L-16071, dated August 1, 2016, from Ralph A. Dodds, III, NextEra Energy Seabrook, to USNRC, "License Amendment Request 16-03, Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16216A240).

2. Letter SBK-L-16153, dated September 30, 2016, from Ralph A. Dodds, III, NextEra Energy Seabrook, to USNRC, "Supplement to License Amendment Request 16-03, Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction (ADAMS Accession No. ML16279A048).

3. MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations," July 2016 (ADAMS Accession No. ML16216A241).

4. MPR-4273, Revision 0, "Seabrook Station – Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction," July 2016 (ADAMS Accession No. ML16216A242).

5. Simpson Gumpertz & Heger, Inc., "Evaluation and Design Confirmation of As-Deformed CEB, 150252-CA-02," Revision 0, July 2016 (ADAMS Accession No. ML16279A049).

Regulatory Requirements

The regulatory requirements below apply generically to all requests for additional information (RAIs). Additional regulatory requirements specific to an RAI are stated in the background section of the RAI. The numbering of the RAIs is a continuation from the RAIs issued by letter dated August 4, 2017 (ADAMS Accession No. ML17214A085).

Section 3.1 of the Seabrook Station, Unit No.1 (Seabrook), Updated Final Safety Analysis Report (UFSAR) discusses how the principal design features for plant structures, systems, and components important to safety meet the U.S. Nuclear Regulatory Commission (NRC) General Design Criteria (GDC) for Nuclear Power Plants specified in Appendix A to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 and identifies any exceptions that are taken. This section indicates that the principal design features for Seabrook structures did include, among others, meeting the requirements of GDC 1, 2, and 4 of 10 CFR Part 50, Appendix A.

GDC 1, "Quality standards and records," requires structures be designed and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be evaluated to determine their applicability, adequacy, and sufficiency, and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. Based on the license amendment request (LAR) and UFSAR Section 3.8, the Seabrook seismic Category I concrete structures, other than containment, were designed in accordance with American Concrete Institute (ACI) 318-71, "Building Code Requirements for Reinforced Concrete," while the containment was designed in accordance with American Society of Mechanical Engineers (ASME) Section III, Division 2, 1975 Edition.

Section III, "Design Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, requires that the design control measures shall assure that applicable regulatory requirements and the design basis, as defined in 10 CFR 50.2, and as specified in the LAR for applicable structures, are correctly translated into specifications, drawings, procedures, and instructions. These measures shall include provisions to assure that appropriate quality standards are specified and included in design documents and that deviations from such standards are controlled. Design changes, including field changes, shall be subject to design control measures commensurate with those applied to the original design.

RAI-D2

Background

The LAR requests approval of a generic methodology for analyzing and evaluating alkali silica reaction (ASR)-affected structures. LAR Section 3.3.2 states that a "Stage Three: Detailed Evaluation" considers cracked section properties, self-limiting secondary stresses, and the redistribution of structural demands when sufficient ductility is available; however, no detail is provided on the implementation of these methods.

Issue

The implementation of the analysis methods stated to be used in the Stage Three portion of the proposed method of evaluation are not clearly explained, and their implementation may constitute a deviation from the analysis methods in the current licensing basis. The LAR does not request to use analysis methods that deviate from the current licensing basis, nor provide technical justification supporting the use of these methods. Furthermore, there is not sufficient guidance provided in the LAR explaining how the methods will be applied in a consistent, repeatable manner as a generic methodology.

Request

Provide a detailed explanation of how the Stage Three analysis methods will be implemented in a consistent, repeatable manner. If the method of evaluation includes departures (or is modified or supplemented) from the existing design code of record, these deviations should be identified, and a technical justification should be provided of how the proposed alternative provides an acceptable method of complying with applicable NRC regulations or portions thereof. Update the LAR and the UFSAR to incorporate any changes based on this RAI response.

RAI-D3

Background

LAR Section 1.0 proposes to revise the UFSAR to include methods for analyzing seismic Category 1 structures with concrete affected by ASR. LAR Section 1.0 states that the Seabrook seismic Category I structures, other than containment, were designed in accordance with ACI 318-71, while the containment was designed in accordance with ASME Section III, Division 2, 1975 Edition. LAR Section 3.3.2 states that for the "Stage Three: Detailed Evaluation":

> The structure is evaluated using strength acceptance criteria in ACI 318-71 for reinforced concrete consistent with UFSAR Section 3.8.4.5. In the Stage Three evaluation, consideration is given to cracked section properties, self-limiting stresses, and the redistribution of structural demands when sufficient ductility is available.

ACI 318-71, Section 8.6, includes provisions for moment redistribution of negative moments calculated by elastic theory at the supports of continuous flexural members. This code section specifies a moment redistribution limit as a function of the tension reinforcement ratio and reinforcement ratio producing balanced conditions, subject to an upper limit of 20 percent. ACI 318-71 allows the use of such moment redistribution only when the section at which the moment is reduced is so designed that the tension reinforcement ratio is equal to or less than 0.5 times the reinforcement ratio producing balanced conditions, as defined in Section 10.3.3 of the code (i.e., the section design has sufficient ductility). The NRC staff notes that no deviations or alternatives from ACI 318-71 provisions (along with sufficient justification) have been proposed in the LAR.

Issue

From the NRC staff review of the Containment Enclosure Building (CEB) Evaluation Report, it is not clear how the moment redistribution approach described in the report meets the criteria in ACI 318-71 or other accepted concrete codes. Specifically, the staff notes the following:

a. The LAR indicates that the design is performed in accordance with ACI 318-71 and considers the redistribution of structural demands when sufficient ductility is available. The CEB report indicates that moment redistribution is used when the axial-flexure (PM) interaction demands exceed their code capacity; however, the CEB report does not appear to address ACI 318-71, Section 8.6, or other requirements to be met for using moment redistribution.

b. The capacity of concrete structures to absorb inelastic rotations at plastic-hinge locations is not unlimited; therefore, the analysis should consider not only the amount of rotation required at critical sections to achieve the assumed degree of moment distribution, but also the rotation capacity of the members at those sections to ensure it is adequate. It does not appear there are specific acceptance criteria for the structural adequacy of a concrete section that develops a plastic hinge. In the case of the CEB, only the strain in the reinforcing steel was calculated.

c. It is not clear if there is a limit on redistribution with the current moment redistribution approach or how the process works if subsequent iterations cause excess moments to occur in the first set of location(s) (e.g., what occurs if convergence to a valid set of results everywhere is not achieved).

Request

a. Explain with sufficient technical detail how the proposed moment redistribution approach meets specific requirements of ACI 318-71 that may be applicable. Provide technical justification for any portions that deviate from the code requirements. Provide the technical basis for concluding that ACI 318-71 covers the use of moment redistribution for structures receiving a Stage Three analysis. Identify any industry codes, standards, guides, published research, and test data that substantiate the deviations.

b. Provide the acceptance criteria and technical basis for the criteria for the structural adequacy of a concrete section that develops a plastic hinge. As an example, acceptance criteria for design parameters to demonstrate the structural adequacy may include limitations on the steel to concrete ratio, permissible ductility ratio (in terms of total displacements of the concrete section) or rotational capacity, and ensuring that flexure, not shear, controls the design.

c. Explain if there is a limit or criteria on the amount of moment redistribution allowed in the proposed process and explain the process when moment redistribution does not provide convergence to a valid set of results in all locations.

d. Update the LAR, UFSAR section markups, and other Seabrook design documents, as applicable, consistent with the responses to this RAI.

RAI-D4

Background

During a June 5, 2017, to June 9, 2017, site audit, the NRC staff reviewed CEB evaluation report, SG&H 150252-CA-02, Revision 0, Seabrook FP#100985, July 2016. Appendix L of this report describes the procedure to implement moment redistribution in the finite element model. It describes the "simplified moment redistribution" method, where after applying all the factored load(s) for the load combination, the excess moment above the code section capacity is determined. Then, the excess moment is redistributed in a separate analysis. Superposition of the two analyses is used to determine the result after initial moment redistribution. If there are locations where the moment exceeds the code section capacity, the process is repeated until all locations fall under the code section capacity.

Issue

Based on the NRC staff's review of the procedure, it would appear to be necessary that all analyses in the sequence be performed using the same structural model and boundary conditions, since results from different analyses are superposed.

Request

To ensure that the NRC staff has correctly interpreted the procedure described in Appendix L, confirm that the same structural model and boundary conditions are used for all analyses in the sequence. If this is not the case, describe the different models used and provide the technical basis for using different models, including the validity of superposing results obtained from different models.

RAI-D5

Background

In LAR Section 3.3.2, the licensee states that original design loads will be combined with the self-straining loads from ASR expansion, and a three-stage process is proposed for analyzing ASR-affected structures. In this discussion, a "threshold limit" is introduced for monitoring ASR effects for each structure. The threshold limit is the value for each monitoring element at which the factored self-straining load equals the design limit when combined with the factored design-basis loads. In a Stage One analysis, an acceptance limit of 90 percent is placed upon the threshold limit. In a Stage Two analysis, a limit of 95 percent is used. In a Stage Three analysis, a limit of 100 percent is used.

Issue

For Stage One and Stage Two analyses, existing design-basis analysis methods are used, and the threshold limit represents the margin remaining between the code allowable limits and the design-basis loading, plus the self-straining loads from ASR.

In Stage Three, additional analysis methods are employed (100-40-40, cracked section properties, moment redistribution), and a threshold factor is applied to account for future ASR expansion. Section 7.3 of the CEB evaluation report states, "The threshold factor is selected to be the largest factor in which the structure meets evaluation criteria using the approaches described in this calculation," and a threshold factor of 1.2 is reported for the CEB. However, as discussed in Section 7.6.2 of the CEB evaluation report, Stage Three analysis uses an iterative process that allows moments to be redistributed to demonstrate that demands meet code capacities.

Since the demands upon the structure are being modified in Stage Three analyses, it is not clear what exactly the threshold factor represents or how it will be selected in future Stage Three analyses.

Request

a. Clarify what the threshold factor represents in Stage Three analyses and how the factor will be determined for future analyses (i.e., is the factor always set at 1.2 or does it depend on each analysis).

b. Explain if there is a limit imposed on the extent of analysis that can be used to modify the demands upon a structure and if this impacts the specification of the threshold factor. Provide a technical justification for the adequacy of the limit or justification for the lack of a limit.

RAI-D6

Background

Standard Review Plan 3.7.2 references Regulatory Guide (RG) 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis," for acceptable methods for combining the effects of three directions of earthquake loading. For response spectrum analysis only, RG 1.92, Revision 3, Regulatory Position 2.1, states that either the square-root-of-the-sum of-the-squares (SRSS) or 100-40-40 methods are acceptable.

Part B, "Discussion" (page 7), of RG 1.92, Revision 3, states:

> The 100-40-40 percent rule was originally proposed as a simple way to estimate the maximum expected response of a structure subject to three-directional seismic loading for response spectrum analysis, and is the only alternative method for spatial combination that has received any significant attention in the nuclear power industry.

In the LAR, the licensee has proposed a change to the licensing basis (UFSAR markup) permitting use of the 100-40-40 combination method in accordance with RG 1.92, Revision 3, in addition to the SRSS combination method for combining the effects of three directions of earthquake loading. The licensee's proposed UFSAR markup specifically states:

> A procedure for combining the three spatial components of an earthquake for seismic response analysis of nuclear power plant structures, systems, and components (SSCs) that are important to safety is presented in Subsection C.2.1. The Response Spectrum Method that uses the 100-40-40 percent combination rule, as described in Regulatory Position C.2.1 of this guide, is acceptable as an alternative to the SRSS method. (emphasis added)

Issue

Based on review of the CEB evaluation report and discussions with the licensee during the June 5, 2017, to June 9, 2017, site visit, it is unclear to the NRC staff that the licensee is applying the 100-40-40 spatial combination method in accordance with RG 1.92, Revision 3, and the Seabrook UFSAR markup, which identify that the 100-40-40 spatial combination method is applicable to response spectrum analysis. The CEB calculation instead uses an equivalent static analysis with the 100-40-40 method.

Request

a. Clarify whether the 100-40-40 method will be implemented in equivalent static analyses for ASR-affected structures. If so, provide the technical basis for using the method in conjunction with equivalent static analysis.

b. Clarify the UFSAR markup and the LAR to describe the specific conditions under which the 100-40-40 spatial combination method may be implemented.

RAI-D7

Background

Standard Review Plan 3.7.2 references RG 1.92 for acceptable methods for combining the effects of three directions of earthquake loading. Part B, "Discussion" (page 7), of RG 1.92, Revision 3, states:

> The results of the 100-40-40 spatial combination have been compared with the SRSS spatial combination. Generally, they indicate that the 100-40-40 combination method produces higher estimates of maximum response than the SRSS combination method by as much as 16 percent, while the maximum under-prediction is 1 percent.

The UFSAR markup makes a similar statement regarding the conservatism of the 100-40-40 method; however, the LAR supplement dated September 30, 2016 (response to Item 4 in Enclosure 1), indicates that the switch from SRSS to 100-40-40 is intended to gain additional margin to accommodate the effects of ASR.

Issue

It is not clear how the 100-40-40 method is being implemented, since the UFSAR states it is generally conservative, while the LAR supplement, as above, indicates that the use of 100-40-40 is intended to gain margin. Consequently, the staff requested and reviewed, via the online audit portal, sample 100-40-40 calculations prior to the June 5-9, 2017 site visit. This subject was also discussed during the site visit. Based on its review and the audit discussions, the staff has identified the following issues with the reviewed sample calculation:

a. The calculation provided a description and two examples of how the 100-40-40 method was applied for combining the three directional responses to determine the maximum expected response for a single load component (e.g., in-plane shear or moment). The NRC staff concluded that for a single load component, the method implemented produces the same maximum response as the RG 1.92, Revision 3, method.

   However, it is not clear how the 100-40-40 method is applied when there is a multiple load interaction effect such as satisfaction of the axial force plus moment interaction equations used for design of concrete sections.

b. The calculation includes two loads, E_o and H_e. Based on the method of implementing 100-40-40, the combined $E_o + H_e$ in some cases is less than E_o alone. Inherent in a calculation that produces lower responses for the combination of E_o and H_e, compared to E_o alone, is the potential assumption that there is a defined phase relationship between the two loads. This assumption does not appear to be justified in the calculation.

Request

a. Provide an explanation of the procedure of how multiple load components (e.g., axial force and moment) are combined to perform code interaction checks. Include the technical basis for the method's acceptability. Update the UFSAR markup and the LAR as necessary.

b. Explain, with sufficient technical detail, why the combination of E_o and H_e in some cases is less than E_o alone. If the explanation assumes a phase relationship between E_0 and H_e, provide the technical basis for the assumed phase relationship.

RAI-D8

Background

Seabrook UFSAR Sections 3.8.4.3 and 3.8.4.5 provide definitions and structural acceptance criteria, respectively, of normal operating (service) load conditions and unusual load conditions for seismic Category 1 structures (other than containment). The Seabrook UFSAR Subsection 3.8.4.3.b.1, "Normal Load Conditions," states:

> Normal load conditions are those encountered during testing and normal operation and are referred to in the standard review plan as service load conditions. They included dead load, live load and anticipated transients, and loads occurring during normal startup and shutdown, and .... Normal loading also includes the effect of an operating basis earthquake and normal wind load. Under each of these loading combinations the structures were designed so that stresses are within elastic limits.

The corresponding structural acceptance criteria for normal load conditions in UFSAR Subsection 3.8.4.5.a states: "Structures were proportioned to remain within the elastic limits under all normal loading conditions described in Subsection 3.8.4.3. Reinforced concrete structures were designed in accordance with ACI 318 strength method, which insures flexural ductility by limiting reinforcing steel percentages and stresses. Similar current licensing basis information is provided in UFSAR Subsections 3.8.3.3 and 3.8.3.5, and 3.8.1.3 and 3.8.1.5, for containment internal structures and containment, respectively.

The UFSAR markup for Sections 3.8.1.3(f), 3.8.3.3(e), and 3.8.4.3a.1(e), incorporated ASR load as a design-basis self-straining load, and states, in part: "ASR loads are passive and therefore occur during normal operation, shutdown conditions, and concurrently with all extreme environmental loads." Thus, ASR is a service load that exists on a day-to-day basis during normal operating or service conditions of the plant.

As required by GDC 1, where generally recognized codes and standards are used, they shall be evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. It is noted that ACI 318-71, the construction code-of-record for seismic Category 1 structures (other than containment) at the Seabrook Station, did not consider ASR effects in its code provisions and that ASR is not a typical design-basis load. The design philosophy in ACI 318-71 includes considerations of strength, as well as serviceability (e.g., Sections 9.1.2, 9.5) requirements intended to limit conditions that may adversely affect the strength or serviceability of the structure at service load levels.

Issue

LAR Section 3.2.2, under the title "Reinforcement Steel Strain," states:

> The expansion of concrete from ASR-induced cracking imposes a tensile strain on steel reinforcement within the affected material. For structures designed to ACI 318-71, the design code allows for reinforcement strains beyond the yield point of the steel bars for flexural elements to prevent brittle compression failure of the concrete in bending. The added strain to the reinforcement should be evaluated in conjunction with the strains imposed by other loads on the structure.

As noted above, the design code allows for reinforcement strains beyond yield for determining the flexural capacity in strength design for comparison against ultimate (factored) loads. However, under realistic (unfactored) normal operating or service load conditions, the design code ensures stresses and strains will remain within elastic limits through serviceability considerations. ASR expansion is a self-straining service load whose progression has potential for straining the reinforcement beyond yield under normal operating conditions. The progression or sustenance of the prestressing effect with ASR expansion and concrete cracking is not well understood or documented, especially if rebar is strained beyond yield due to ASR.

As required by the structural design in the Seabrook UFSAR, stresses and strains in the structures shall be maintained within elastic limits under normal operating load conditions. Potential yielding of the rebar due to ASR under service conditions could be indicative of a marked change in the behavioral response of a structure, could impact structural capacity, and can render assumptions of linear-elastic behavior in the structural analyses (including seismic analyses) unjustified. However, the proposed method of structural evaluation for ASR-affected structures, which includes provisions for cracked sections and redistribution of structural demand, does not appear to include a verification of the concrete and rebar stresses and strains based on realistic behavior under normal operating conditions (including ASR) that would ensure they remain within elastic limits, as required by the UFSAR.

Request

Explain, with sufficient technical detail, how the proposed method of evaluation (Stage One, Stage Two, and Stage Three) for ASR-affected structures verifies that the stresses and strains in the concrete and reinforcement remain within elastic limits based on realistic behavior under normal operating (service) load conditions, including ASR load. Update the UFSAR markup and the LAR as necessary based on the response.

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