NRR-PMDAPEm Resource

From:	Poole, Justin
Sent:	Monday, September 11, 2017 1:44 PM
To:	Browne, Kenneth
Cc:	Danna, James
Subject:	DRAFT - Request for Additional Information Regarding ASR Amendment Request
Attachments:	DRAFT - MF8260 Stage 3 RAIs.pdf

Ken

By letter dated August 1, 2016, as supplemented by letter dated September 30, 2016, NextEra Energy Seabrook, LLC (NextEra) submitted a license amendment request for Seabrook Station, Unit No. 1. The proposed amendment would revise the current licensing basis to adopt a methodology for the analysis of seismic category I structures with concrete affected by alkali-silica reaction. In reviewing NextEra's application, the NRC staff has developed the attached DRAFT request for additional information (RAI). Some of these DRAFT RAIs were first transmitted to you on May 5, 2017. Furthermore, these RAIs had been previously withheld from our August 4, 2017, RAIs (ADAMS Accession No. ML17214A085) and were a topic of discussion at the public meeting on August 24, 2017, regarding the NRC staff's concerns with your Stage Three evaluations.

Please review these revised DRAFT RAIs to ensure that the questions are understandable, the regulatory basis is clear, there is no proprietary information contained in the RAI, and to determine if the information was previously docketed. Please let me know if a clarification call is desired to ensure the questions are fully understood. This email does not convey a formal NRC staff position, and it does not formally request for additional information.

Justin C. Poole
Project Manager
NRR/DORL/LPL I
U.S. Nuclear Regulatory Commission
(301)415-2048

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Created By: Justin.Poole@nrc.gov

Recipients:
"Danna, James" <James.Danna@nrc.gov>
Tracking Status: None
"Browne, Kenneth" <Kenneth.J.Browne@nexteraenergy.com>
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REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING LICENSE AMENDMENT REQUEST (LAR) 16-03 TO REVISE CURRENT LICENSING BASIS TO ADOPT A METHODOLOGY FOR THE ANALYSIS OF SEISMIC CATEGORY I STRUCTURES WITH CONCRETE AFFECTED BY ALKALI-SILICA REACTION,
NEXTERA ENERGY SEABROOK, LLC,
SEABROOK STATION
DOCKET NO. 50-443

References:

1. Letter SBK-L-16071, dated August 1, 2016, from Ralph A. Dodds III, NextEra Energy Seabrook to USNRC regarding the Request to Adopt a Methodology for Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction (ADAMS Accession No. ML16216A240).
2. Letter SBK-L-16082, dated September 30, 2016, from Ralph A. Dodds III, NextEra Energy Seabrook to USNRC regarding the Supplement to Request to Adopt a Methodology for 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 Requirement

The regulatory requirements below applies generically to all RAIs. Additional regulatory requirements specific to an RAI is 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 UFSAR discusses how the principal design features for plant structures, systems and components important to safety meet the NRC General Design Criteria (GDC) for Nuclear Power Plants, specified in Appendix A to 10 CFR Part 50 and identifies any exceptions that are taken. This section indicates, in part, that the principal design features for Seabrook structures did include, among others, meeting the requirements of General Design Criteria (GDC) 1, 2 and 4 of 10 CFR 50, Appendix A.

10 CFR Part 50, Appendix A, GDC 1, Quality Standards and Records, requires, in part, 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 LAR and UFSAR Section 3.8, the Seabrook seismic Category I concrete 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.

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10 CFR Part 50, Appendix B, Criterion III "Design Control" requires, in part, 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 license application, 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.

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RAI-D2

Background

The LAR requests approval of a generic methodology for analyzing and evaluating 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 analysis methods described in the Stage Three portion of the evaluation are not clearly explained and appear to constitute deviations from the analysis methods currently in the UFSAR. The LAR does not request to use analysis methods that deviate from the current UFSAR, nor provide technical justification supporting the use of these methods. Furthermore, there is no guidance provided in the LAR or the UFSAR markup explaining how the methods will be applied in a consistent, repeatable manner.

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," "[t]he 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.

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Issue

From the 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:

1. 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 the ACI 318-71, Section 8.6, or other, requirements to be met for using moment redistribution.

2. 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.

3. 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

1. 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.

2. 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.

3. 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.

4. 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 5-9, 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, while in a Stage Three a limit of 100 percent is used.

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Issue

For Stage One and 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

1. 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).

2. 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:

SRP 3.7.2 references Regulatory Guide (RG) 1.92 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 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 Mark-up), 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 Mark-up specifically states:

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> 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 CEB evaluation report, and discussions with the licensee during the June 5-9, 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 Mark-up, which identify that the 100-40-40 spatial combination method is applicable to response spectrum analysis (RSA). The CEB calculation instead uses an equivalent static analysis with the 100-40-40 method.

Request:

1. 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.

2. Clarify the UFSAR mark-up and the LAR, to describe the specific conditions under which the 100-40-40 spatial combination method may be implemented.

RAI-D7

Background:

SRP 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 in the LAR makes a similar statement regarding the conservatism of the 100-40-40 method, and 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 that implementation of the 100-40-40 method is in strict adherence with RG 1.92, Revision 3. Consequently, the NRC 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 NRC staff has identified the following issues with the reviewed sample calculation:

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1. 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. Consistent with RG 1.92, Revision 3, the expected maximum axial force (F) would be calculated separately, the expected maximum moment (M) would be calculated separately, and then four permutations (+F/+M; +F/-M; -F/+M; -F/-M) would be evaluated using the interaction equations. The NRC staff was unable to verify this method is being used when the 100-40-40 method is applied.

2. 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 assumption that there is a defined phase relationship between the two loads. This assumption does not appear to be justified in the calculation.

<u>Request</u>:

1. Provide an explanation of the procedure of how multiple load components (e.g., axial force and moment) are combined to perform code interaction checks. If the method is different from that described in Issue 1 above, provide the technical basis for its acceptability.

2. 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:

LAR Section 3.2.2 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.

The above view is also indicated in Section 6.1.1 of report MPR-4288 (Enclosure 2 of LAR). Additionally, the LAR and the UFSAR markup for Sections 3.8.3.3(e) and 3.8.4.3a.1(e) incorporated ASR load as a design basis load, and states, “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 (i.e., exists on a day-to-day basis during normal operating or service conditions of the plant).

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ACI 318-71 ultimate strength design (USD) philosophy includes both a limit state of collapse as well as limit state of serviceability to limit conditions (e.g., Sections 9.1.2, 9.5) which may adversely affect the strength or serviceability of a structure at service loads. The serviceability limits also ensure linear-elastic behavior of the structure under normal operating conditions assumed in the structural analysis. Serviceability limit states are assessed under actual normal service loads (i.e., using a load factor of 1.0). Section 9.1.2 of ACI 318-71 states that members shall also meet all other requirements of the code to ensure adequate performance at service load levels.

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 Seabrook, did not consider ASR effects in its code provisions.

Issue:

The above mentioned statement in the LAR regarding the design code allowing for reinforcement strains beyond yield is true in calculating flexural capacity at ultimate loads if and when the structure is loaded to failure; however, it is not true to assess serviceability limit states (for deflection, crack control, etc.) under normal service conditions (i.e., normal service loads with a load factor of 1, including ASR, in a load combination). Unlike other service loads, ASR is a service load that may progress at a slow but unknown rate. ASR also causes an internal prestressing effect that results in tensile strain in reinforcing steel and compressive stress in concrete.

An underlying assumption of concrete design, and in the structural analysis, is that rebar strains will not go into the yield region under normal service load conditions; i.e., the structure exhibits elastic behavior under service loads. However, the staff noted that the method of structural evaluation proposed in the LAR for ASR-affected structures, as well as in the CEB Report, does not appear to include an assessment of net rebar strain under normal operating conditions including ASR. Without this assessment, it is not clear how the licensee will identify and evaluate locations with potential for rebar yielding under service conditions and ensure the general linear-elastic behavior of the structure under normal operating conditions assumed in the structural analysis.

As an analogous requirement related to prestressing effects in concrete, the provisions for prestressed concrete design in Chapter 18 of ACI 318-71 explicitly limits the permissible stress in prestressing tendons to a value below yield after transfer or anchoring of prestress (see Section 18.5.2). The general design considerations in Section 18.2.1 states, in part: “Design shall be based on strength and on behavior at service conditions at all load stages that may be critical during the life of the structure from the time the prestress is first applied.” The staff also notes that Section 5.3.4 of MPR-4273 states: “$P_{service}$ (Point D) is the load on the test specimen at the service-level condition (defined by ACI as 60 percent of the flexural yielding load).”

Request:

Explain, with sufficient technical detail and acceptance criteria, how the limit state of serviceability is addressed under controlling normal operating or service load conditions (which includes ASR load) in the proposed method of evaluation for ASR-affected structures at

Seabrook Station, specifically with regard to assessment of net rebar strain to address potential for rebar yielding due to ASR expansion under service conditions. Alternately, provide justification and supporting technical basis as to why such a check is not necessary.

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