PRELIMINARY DRAFT RESPONSE TO REQUEST FOR TECHNICAL ASSISTANCE
FOR SEABROOK STATION
ALKALI-SILICA REACTION DEGRADATION OF CONCRETE
(PREDECISIONAL - OFFICIAL USE ONLY
FOR INTERNAL BRAINSTORMING & COMMENT)

1.0 INTRODUCTION

By letter dated September 12, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML1116105300), the U.S. Nuclear Regulatory Commission (NRC) Region I Office requested technical assistance from the Office of Nuclear Reactor Regulation (NRR) to evaluate the potential consequence of alkali-silica reaction (ASR) degradation of a safety-related concrete structure at Seabrook Station. More specifically, based on NRR review for adequacy of a NextEra prompt operability determination (POD) and its associated open issues, NRC staff should be able to identify what additional information is needed in order to fully evaluate the impact of the degradation on the current licensing and design basis in the final operability determination for structures important-to-safety at the plant. As the primary case for review, NextEra evaluated the Seabrook Control Building ("B" Electrical Tunnel and Penetration Room) in light of the recently discovered degradation mechanism. Other structures important-to-safety within the scope of the maintenance rule have also been affected by the ASR problem.

Region I requested NRR assistance to address the above concerns by providing answers to the five Task Interface Agreement (TIA) questions which are stated in Section 3.0 "Evaluation" of this response.

2.0 BACKGROUND

NextEra Energy (the licensee) analyzed concrete core samples from the interior surface of exterior walls of the Control Building as part of their assessment to support renewal of their license. In August 2010, tests undertaken as a part of the core sample analysis reported a change in material properties. The analysis reported the presence of ASR-degradation in core samples taken from chronically wet walls below grade, with reductions reported in the concrete compressive strength and modulus of elasticity from that expected. NextEra evaluated these parametric reductions to determine the impact on the design basis of the Control Building. By their process, the licensee performed an immediate and prompt operability determination (POD) and concluded, preliminarily, that the Control Building (CB) was operable but with reduced strength reserves to design capacity.

NextEra continued to evaluate the extent of this condition for five other safety related concrete buildings. The other five buildings for which concrete core samples were taken were: Equipment Vault (housing ECCS equipment including that for Residual Heat Removal (RHR)], Radiological Controls Area (RCA) Walkway, Emergency Feedwater Building (EFW), Emergency Diesel Generator (EDG) Building, and the Containment Enclosure Building (CEB). As of June 30, 2011 there are two open prompt operability determinations, one for the Control Building and one for the other five buildings collectively. The licensee found additional evidence of ASR in four of the five other buildings and they evaluated that information in a separate immediate and prompt

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operability determination using the same evaluation techniques as for the Control Building. This evaluation is also considered preliminary or open. Based on NRC internal discussions, it appears that the calculation methods and correlations that NextEra used in their prompt operability determination may not be fully appropriate in light of the ASR problem.

NextEra's planned actions are two-fold: 1) to follow their operability determination process; and, 2) to follow the guidance in NEI 95-10, "Industry Guideline for Implementing the Requirements of 10 CFR Part 54 – The License Renewal Rule," to develop an aging management program to support the license renewal application. Possible outcomes to the PODs are: 1) restored conditions (which may not be possible); 2) resolved conditions (use "as is" by procedure change incorporated or Action Request (AR) disposition approved); or 3) current licensing basis (CLB) revised (e.g., 10 CFR 50.59 evaluation). The licensee has posted on the Certrec internal website their operability determination process for reference (EN-AA-203-1001_005, No. 1 on Certrec Document Tab List).

NextEra's proposal related to license renewal was described in a letter dated April 14, 2011, under the response to NRC request for additional information B.2.1.31-1 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML11108A131). This letter describes periodic reviews for operability as information is developed to support the aging management review. At the time, the proposal included another analysis (termed "final" by NextEra) of the impact of ASR on the current licensing and design basis, including the extent of the condition, to be completed by June 2011. Since that letter and as noted above, the control building POD was kept open; a new immediate and POD were completed for the other five building core sample results that were involved in an extent of conditions review. The subject NextEra letter also commits to an Engineering Evaluation to be completed in March 2012. On June 29, 2011, the NRR Division of License Renewal issued another "Request for Additional Information" (ADAMS Accession No. ML11178A338) related to key aspects of NextEra's comprehensive plan for assessing the ASR problem for the Structures Monitoring Program including that for the Fuel Handling Building and Containment ("Followup RAI B2.1.31-1, B2.1.31-4, and B2.1.28-3). The response to this letter dated August 11, 2011, (ADAMS Accession No. ML112227A0230) does not reflect a comprehensive plan for determining operability/functionality of affected buildings along with plans for the development of aging management review and program.

With respect to Part 50 requirements, Region I reviewed the NextEra current Structures Monitoring Program and found a violation of the maintenance rule for the control building. The finding is described in detail in NRC Inspection Report 05000443/2011002 (ADAMS Accession No. ML111330689). More details related to the newly discovered ASR issue were also documented in the NRC Inspection Report 05000443/2011007 (ADAMS Accession No. ML111360432) as part of a license renewal inspection. The cover letter for the latter report notes that the aging management review for the ASR issue is not complete and that there is a need for a continuing review in the Part 50 and 54 areas. The staff of Region I and NRR (Division of Engineering and Division of License Renewal) have been discussing actions since January 2011 to ensure that the Part 50 and 54 reviews are coordinated.

The documents listed below were made available for review on the licensee's "Certrec" internal website (Certrec Document Library Tab List). These documents reflect current NextEra view of operability for the Control Building and the associated tunnel and penetration room. The

"Certrec" system was set up in order to facilitate NRC staff access to NextEra's internal documents. The NRC staff was requested to inform Region I and NextEra if the document is to be printed, for review purposes, prior to doing so.

1. C-S-1-10159 CALC_000, Rev. 0, 'B' Electrical Tunnel Transverse Shear Evaluation Supplement to Calculation CD-20

2. C-S-1-10150 CALC_000, Rev. 0, Effects of Reduce Modulus of Elasticity – 'B' Electrical Tunnel Exterior Walls

3. CD-20-CALC, UE Control and Diesel Generator Building Design of Material and Walls below grade for Electrical Tunnel and the Control Building (Original Design Calculation)

4. Action Request (AR) 581434 Prompt Operability Determination Reduced Concrete Properties Below Grade in 'B' Electrical Tunnel Exterior Walls.

On April 27, 2011, NRR Division of Engineering provided support by performing an initial review of NextEra's basis for acceptability of the reduction in modulus of elasticity in light of concrete core testing which supported 10 CFR 50.59 screening process without prior NRC staff review and approval. This evaluation and its related design change document accept the reduced parameters of compressive strength and modulus of elasticity for the Control Building and the Containment Enclosure Building as a potential disposition for the operability determination (Certrec Document Library Tab List, Enclosure Bldg and Control Bldg MSP – Design Change Package Description No. EC-272057, Rev. 000, Concrete Modulus of Elasticity Evaluation). The staff questioned the adequacy of this screening action.

The licensee is also planning an apparent cause review for the maintenance rule violation noted above. Corrective actions include a comprehensive walkdown of all structures important-to safety with suspected ASR condition in accordance with a revised structures monitoring program procedure that meets the latest ACI standard in the area (ACI 349.3R-02). This has been completed for the control building, containment enclosure building, and the containment. Completion of these assessments for the other buildings is tentatively December 2011. Further, the licensee plans to conduct a root cause evaluation of the ASR issue which should be completed in time for incorporation into the planned March 2012 Engineering Evaluation as noted above.

Licensee Position

To date, within the limitations of their testing and analysis, NextEra determined that none of the seismic category I structures tested have been found to be outside their design basis and were, therefore, operable with extent of conditions questions needing be addressed. The Seabrook design and licensing basis to which the licensee made these determinations was documented in UFSAR Section 3.8. NextEra is willing to address the additional questions from the NRC staff; but, it is uncertain if those questions will be addressed in the final operability determination tentatively scheduled for September 30, 2011. It also remains uncertain what NextEra's comprehensive plan is based on review of their August 11, 2011, response to NRC letter of June 29, 2011.

In light of the newly discovered ASR issue, it appears that NextEra technical personnel are developing new insights for what key aspects must be addressed in the final operability determination for any building with evidence of ASR. NextEra is considering NRC staff questions to date and has hired consultants in this area. These consultants also will be developing a new model for the Containment Enclosure Building load analysis.

[*It should be noted that NextEra's schedule indicated in the above paragraph has changed and the prompt operability determinations were revised*

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Recommended Actions by Region I

In order for Region I to independently determine operability of the control building or any other important-to-safety structure affected by the ASR problem; and, as a primary case, we need a review for adequacy of the control building prompt operability determination and any related open issues as identified by NextEra. This information would be applied to the final operability determination for the control building and any other affected important-to-safety structures. The important-to-safety structures affected by the ASR problem are within the scope of the maintenance rule and are also consistent within the scope of license renewal. More specifically we need to independently develop a comprehensive set of issues to be applied to any final operability determination as a part of our oversight of the licensee's process and any new insights gained from NextEra's technical research.

Accordingly, Region I requests that NRR evaluate the adequacy of NextEra's control building prompt operability determination and its related open issues with particular focus, but not limited to, the below listed key technical questions. The licensee has provided a set of documents as noted on the "Certrec" website referenced above, but the NRR review should not be limited to those documents. Region I will facilitate ensuring that additional documents, as needed, are available on the website or, as necessary, by an onsite inspection. NRR's determination should enable the staff to confirm that there is reasonable assurance of continued operability given the concrete degradation identified due to ASR for the control building once the final operability determination is made by NextEra for this or any other important structure affected by the ASR problem.

During the course of this review, Region I requests that NRR specifically identify any concerns with the assumptions, methodologies, or calculations, etc., along with the regulatory or other basis of each concern; and, notify Region I immediately if NRR finds that any of the reviewed documents for the control building do not provide reasonable assurance of continued operability of that building. As a minimum, the response to this TIA should include an independently developed comprehensive set of issues to be addressed in the final operability determination for the Control Building in order for us to further assess the licensee's process and their new insights gained for all important-to-safety structures with evidence of ASR.

3.0 EVALUATION

Question 1:

Working with Region I staff in an inspection forum, NRR staff should identify a comprehensive list of issues that need to be addressed in the final operability determination for the Control Building, given the current view of operability by NextEra as reflected in the prompt operability determination.

[Discussion by Region 1: NRC staff identified questions as listed in the NRC RAI [(ADAMS Accession No. ML11178A338) dated June 29, 2011. The questions related to key aspects of NextEra's comprehensive plan for assessing the ASR problem for the Structures Monitoring Program, including that for the Fuel Handling Building and Containment (Followup RAI B2.1.31-1, B2.1.31-4, and B2.1.28-3)]. If the issues are initially considered comprehensive, please give consideration to the below additional views produced by the regional technical staff. If those issues are not considered comprehensive, then identity those additional issues to be included with consideration to those listed below along with regulatory or other basis for the concern. An example would be the need for Poisson ratio calculations on core samples because there are assumed numbers in the UFSAR or the need for stiffness damage tests because of applicable ACI standard requires it in the current licensing basis.]

Response:

The NRR staff notes that reference to the Control Building in TIA 2011-13 refers to the "B" Electrical Tunnel, which runs below the Control Building foundation.

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This TIA response will hereafter use the designation of "B" Electrical Tunnel rather than Control Building for the ASR affected structure that is the subject of the TIA.

The Electrical Tunnels are Seismic Category 1 reinforced concrete structures designed to house the Train A and Train B safety-related cable/cable-tray systems in train independent structures. The structure protects the safety-related systems, equipment and components located inside the Electrical Tunnels against all postulated external environmental conditions.

The Electrical Tunnels structure is designed to withstand all credible conditions of loading, including normal loads, severe environmental loads, extreme environmental loads, and abnormal loads. The loads included ground water hydrostatic pressure, OBE and SSE loads.

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Question 2:

Because the original design basis assumes no ASR is present during the design life of the structure, what, if any, are the specific original design assumptions affected by the presence of ASR that are not clearly evident in the UFSAR design basis?

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[Discussion by Region 1: For example several calculation methods such as the relationship between compressive strength and modulus of elasticity to shear capacity and shear force are used in the seismic analysis. These assumed relationships may not be valid with ASR present in the structure.]

Response:

(a) The design basis of the Seismic Category 1 Structures affected by ASR, including the "B" Electrical Tunnel is described in Seabrook Station UFSAR (Reference 14), Section 3.8.4 "Other Seismic Category 1 Structures." UFSAR Section 3.8.4.4.a states that reinforced concrete design of Category 1 structures was in accordance with the strength design procedures of the **ACI 318-71 code** (Reference 22), except as indicated in Subsection 3.8.4.5. UFSAR Section 3.8.4 contains physical descriptions, codes, loads and load combinations, design and analysis procedures, structural acceptance criteria (e.g., allowable stresses), quality control, and testing requirements of Seismic Category 1 structures exclusive of the containment structure and its internals. The basic load combinations considered in the design of each seismic Category 1 structures are given in UFSAR Table 3.8-16

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UFSAR Section 3.8.4.5.d states that no special allowance has been made for variation of material properties over the life of the structure, beyond that which is taken into account in establishing allowable stresses, strains, capacity reduction factors, concrete protection of reinforcing, and crack control as outlined in the referenced ACI and AISC codes. Additional corrosion protection is provided to concrete structures by means of

waterproofing for parts of the structure below grade and by painting, coating or installing of liners for structural concrete tanks (such as the spent fuel pool).

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Question 3:

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What is the appropriate ACI standard to be used for degraded concrete core sampling assessing in-situ ASR degradation for the control building (locations, numbers, frequency of sampling in the future, etc)?

[Discussion by Region 1: While this is an issue raised based on staff questioning, we need to know the regulatory or other basis for the use of either of two applicable standards or other more appropriate standard. One standard is ACI 228 used by NextEra for correlation to penetration resistance probe data and the other is ACI 214 (version 1965 is referenced in the UFSAR section 3.8.2.4). It should be further noted that a later revision of ACI 214 (ACI-214.R-03) provides for additional sampling in order to achieve a 95% confidence level. The ACI 228 appears to be met by NextEra but it requires less sampling. These standards were developed for general design and construction of concrete structures for non-nuclear applications. Technical research may be needed in order to determine their relevance for nuclear application in which the structures are heavily reinforced with rebar.]

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Question 4:

Did NextEra perform adequate laboratory tests for core sampling, including appropriate parameters obtained along with laboratory test conditions?

[Discussion by Region 1: Also, during the course of this review, please identify the need for any in situ testing of control building conditions including appropriate parameters to be obtained such as temperature and humidity along with test conditions for now and in the future. Also, provide guidance on where and how much rebar should be exposed in order to assess the effect on rebar from the ASR issue.

No tensile strength testing is being performed on the concrete core samples and this question was raised in the RAI in terms of how shear capacity is being determined. However, the Region I staff believe that the specific parameter of tensile strength of concrete may not be sufficiently accurate and therefore relevant in a constrained structure. As the pressure load from the ASR gel increases, that load may be transferred to the rebar. Available research in this area appears to be conflicting. The UFSAR for containment assume concrete in reinforced systems provide no tensile strength.

A core sample with ASR does not represent the forces contained in the structure because for this test, in particular, elastic rebound is not considered. For split tensile tests on core samples, the frictional influences in the test itself are not accommodated. The frictional losses are further exacerbated by the standard laboratory practice of placing plywood on opposing faces of the tensile specimen to stop it from rolling off the test stand, thus restraining axial expansion of the sample.]

Response:

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Question 5:

Is the current NextEra structural monitoring program sufficient to discover or predict additional ASR damage to structures prior to the damage negatively impacting the design basis of the structure?

[Discussion *by Region 1*: To date three building assessments have been completed: control building, the containment, and the containment enclosure building. These assessments were initiated as a consequence of discoveries made preparing for a renewed license application. These discoveries should be reflected in enhancements to the programs required as part of the Maintenance Rule. The Region requests NRR assistance in evaluating the current acceptability of NextEra's programs to maintain the integrity of the safety related structures.]

Response:

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4.0 REGULATORY REQUIREMENTS

The regulatory requirements pursuant to 10 CFR Part 50 and guidance applicable to addressing the ASR-degradation of concrete in Other Seismic Category 1 Structures at Seabrook, which includes the B Electrical Tunnel, can be found in the following regulations and regulatory documents.

(a) 10 CFR 50.65, Maintenance Rule, as it relates to monitoring the performance and condition of structures, systems, or components (SSCs) in a manner sufficient to provide reasonable assurance that these SSCs are capable of fulfilling their intended functions. When the performance or condition of an SSC do not meet established goals, appropriate corrective action shall be taken.

(b) 10 CFR Part 50, Appendix B, as it relates to the quality assurance criteria for nuclear power plants.

(c) Criterion XVI "Corrective Action" of 10 CFR 50 Appendix B as it relates to implementing a corrective action program to assure that significant conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and non-conformances are promptly identified, cause addressed, and corrected.

(d) 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 1 as it relates to structures, systems, and components being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

(e) 10 CFR Part 50, Appendix A, GDC 2, as it relates to the design of the safety-related structures being able to withstand the most severe natural phenomena such as wind, tornadoes, floods, and earthquakes and the appropriate combination of all loads.

(f) 10 CFR Part 50, Appendix A GDC 4, as it relates to safety-related structures being appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

(g) NUREG-0800, Standard Review Plan, Section 3.8.4 - Other Seismic Category 1 Structures

(h) Regulatory Guide 1.160, Revision 2 (March 1997), Monitoring the Effectiveness of Maintenance at Nuclear Power Plants

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Note: References 1 thru 12 are licensee documents made available on licensee's Certrec website.

1. Calculation C-S-1-10159, Rev. 0, 'B' Electrical Tunnel Transverse Shear Evaluation Supplement to Calculation CD-20
2. Calculation C-S-1-10150, Rev. 0, Effects of Reduce Modulus of Elasticity – 'B' Electrical Tunnel Exterior Walls
3. Calculation CD-20-CALC, UE Control and Diesel Generator Building Design of Material and Walls below grade for Electrical Tunnel and the Control Building (Original Design Calculation)
4. Drawings for Control Building Concrete (Electrical tunnel) 9763-F-111342, 9763-F-111343 and 9763-F-111345
5. Action Request (AR) 581434, Revision 000, Prompt Operability Determination Reduced Concrete Properties Below Grade in 'B' Electrical Tunnel Exterior Walls.
6. Action Request (AR) 581434, Revision 001, Prompt Operability Determination Reduced Concrete Properties Below Grade in 'B' Electrical Tunnel Exterior Walls
7. EC 145305, Condition Assessment of Control Building Concrete
8. AR 574120 Preliminary Test Results of Control Building Concrete
9. AR 581434 Test Results from Control Building Concrete Modulus Testing *(Results of petrographic analysis of 4 of the 12 CB cores identified the presence of moderate to severe ASR in the concrete)*
10. EC250348, Revision 002, Condition Assessment of Building Concrete

11. AR 01625775, Revision 000, Petrographic Analysis of Concrete Cores from Seabrook Station

12. System Description No. SD-66, Revision 2, System Description for Structural Design Criteria for Public Service Company of New Hampshire, Seabrook Station, Unit Nos. 1 and 2, 3/02/84.

13. Structural Engineering Standard Technical Procedure 36180, Revision 01, "Structural Monitoring Program," NextEra Engineering Department Standard, 3-15-2011

14. Seabrook UFSAR, Revision 12, Section 3.8.4, Other Seismic Category 1 Structures

15. NUREG-0800, Standard Review Plan, Section 3.8.4 – Other Seismic Category 1 Structures

16. Regulatory Guide 1.160, Revision 2 (March 1997), Monitoring the Effectiveness of Maintenance at Nuclear Power Plants

17. RIS 2005-20, Revision 1 dated April 16, 2008, Attachment 1 "NRC Inspection Manual, Part 9900: Technical Guidance, Operability Determination and Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety."

18. Letter dated 6-29-2011 from Richard Plasse, USNRC, to Mr. Paul Freeman, NextEra Energy Seabrook, LLC – Request for Additional Information for the Review of Seabrook Station License Renewal Application (b)(5) (b)(5) ML11178A3380)

19. NextEra Energy Letter SBK-L-11154 to USNRC dated 8-11-2011, Docket No. 50-443, Seabrook Station Response to Request for Additional Information – NextEra Energy Seabrook License Renewal Application Request for Additional Information – Set 15 (b)(5)

20. NextEra Energy Letter SBK-L-11063 to USNRC dated 4-14-2011, Docket No. 50-443, Seabrook Station Response to Request for Additional Information – NextEra Energy Seabrook License Renewal Application Request for Additional Information – Set 13 (b)(5) (ML11108A1310)

21. NextEra Energy Letter SBK-L-10204 to USNRC dated 12-17-2010, Docket No. 50-443, Seabrook Station Response to Request for Additional Information – NextEra Energy Seabrook License Renewal Application Aging Management Programs (b)(5) (b)(5) (ML1035405340)

22. ACI 318-71, Building Code Requirements for Reinforced Concrete (with Commentary)

23. ACI 349.3R-02, Evaluation of Existing Nuclear Safety-Related Concrete Structures

24. ASTM C 823/C 823M – 07, Standard Practice for Examination and Sampling of Hardened Concrete in Constructions.

25. ACI 228.1R-03, *In-Place Methods to Estimate Concrete Strength*

26. ACI 214R-02, Evaluation of Strength Test Results of Concrete

27. ACI 214.4R-03, Guide for Obtaining Cores and Interpreting Compressive Strength Results

28. ACI 228.2R-98 (Reapproved 2004), Nondestructive Test Methods for Evaluation of Concrete in Structures

29. ACI 437R-03, Strength Evaluation of Existing Buildings

30. Structural effects of alkali-silica reaction – Technical guidance on the appraisal of existing structures, The Institution of Structural Engineers, London, UK, July 1992 and Addendum, April 2010

31. Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures, US Department of Transportation, Federal Highway Administration, January 2010

32. PCA R&D SN2892b, Evaluation of Alkali-Silica Reaction (ASR) Mortar Bar Testing (ASTM C1260 and ASTM C1567), PCA Durability Subcommittee – Concrete Technology, Portland Cement Association, 2009.

33. Popovics, S., Strength and Related Properties of Concrete – A Quantitative Approach, John Wiley & Sons, Inc., 1998.

34. Nilson, A.H., and Winter, G., Design of Concrete Structures, Eleventh Edition, McGraw-Hill Inc.

35. R. Park and T. Paulay, Reinforced Concrete Structures, John Wiley & Sons, 1975.