UNITED STATES
NUCLEAR REGULATORY COMMISSION

REGION I
475 Allendale Road
King of Prussia, PA 19406

Draft 6

MEMORANDUM TO: Robert A. Nelson, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

FROM: James Clifford, Deputy Director
Division of Reactor Projects

SUBJECT: REQUEST FOR TECHNICAL ASSISTANCE
SEABROOK STATION ALKALI-SILICA REACTION

Region I requests 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 important structures at the plant. As a test case for review, the NextEra evaluation was for the Seabrook Control Building ("B" Electrical Tunnel and Penetration Room) in light of the recently discovered degradation mechanism. Other important strucutures are affected by the ASR problem and they are within the scope of the maintenance rule. Accordingly, additional Task Interface Agreements may be necessary such as for a review of the final operability determination results for other buildings also exhibiting the ASR problem.

Background

NextEra (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 an (ASR) 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 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)], RCA (Radiological Controls Area) 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

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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 operability determination using the same evaluation techniques as for the Control Building - the 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 valid 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 incorporate 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 and a new immediate and POD were completed for the other five building core sample results. 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 is due on or about August 13, 2011 and we expect it to reflect a comprehensive plan for determining operability/functionality of affected buildings along with plans for the development for 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 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 staffs of Region I and NRR (Division of Engineering and License Renewal) have been discussing actions since January 2011 to ensure that the Part 50 and 54 reviews are coordinated.

The below listed documents were made available for review on the licensee's "Certrec" internal website. These documents reflect current NextEra view of operability for the Control Building and the associate tunnel and penetration room. The "Certrec" system was set up in order to

facilitate NRC staff access to NextEra's internal documents. Please inform Region I and NextEra if the document is to be printed, for review purposes, prior to doing so.

1. (No. 2 on Certrec Document Library Tab List) C-S-1-10159 CALC_000, Rev. 0, 'B' Electrical Tunnel Transverse Shear Evaluation Supplement to Calculation CD-20
2. (No. 4 on Certrec Document Library Tab List) C-S-1-10150 CALC_000, Rev. 0, Effects of Reduce Modulus of Elasticity – 'B' Electrical Tunnel Exterior Walls
3. (No. 5 on Certrec Document Library Tab List) CD-20-CALC, UE Control and Deisel Generator Building Design of Material and Walls below grade for Electrical Tunnel and the Control Building (Original Design Calculation)
4. (No. 6 on Certrec Document Library Tab List) Action Request (AR) 581434 Prompt Operability Determination Reduced Concrete Properties Below Grade in 'B' Electrical Tunnel Exterior Walls.

Also, before the startup of Seabrook from a refueling outage in May 2011, on April 27, 2011, NRR Division of Engineering provided support by reviewing the following document - AR No. 1644074 which documents NextEra's basis for acceptability of the reduction in modulus of elasticity in light of concrete core testing using a 10 CFR 50.59 screening process without prior NRC staff review and approval. This document (note that this AR will be on Certrec) is related to a design change document which accepts 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 (No. 10 on 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). While the screening process was questioned by NRC staff, NRR DE provided a list of questions as noted in the attachment (with one question being withdrawn - question No. 7.)

The licensee is also planning an apparent cause review for the maintenance rule violation noted above. Corrective actions include a comprehensive walkdown of all important structures 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 but the completion dates for the other buildings is tentatively August to September 2011. Further, they plan a root cause evaluation of the ASR issue and it 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 attached questions from DE; but, it is uncertain if those questions will be addressed in the final operability determination currently scheduled for September 30, 2011. NextEra will be providing a comprehensive plan on or about August 13, 2011, in response to NRC letter of June 29, 2011, as noted above.

In light of the newly discovered ASR issue, it appears that NextEra technical reviewers 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.

Requested Actions

In order for Region I to independently determine operability of the control building or any other important structure affected by the ASR problem; and, as a test 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 any final operability for the control building and any other important structures. The important structures are those affected by the ASR problem and are within the scope of the maintenance rule which are also consistent with those within the scope for 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 reference Certrec website above but the NRR review should not be limited to those documents. Region I will facilitate ensuring that additional documents, as needed, are 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 are made by NextEra for this or any other important structure affected by the ASR problem.

In 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 the 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 structures with evidence of ASR.

1. Do the referenced questions represent 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: The reference questions are those listed in the attachment of this document and those questions posted in the NRC RAI request for additional information [(ADAMS Accession No. ML11178A338) dated June 29, 2011, 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 the 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 stiffness damage tests because of applicable ACI standard requires it in the current licensing basis.

2. What is the importance of tensile strength measurements on core samples, and distinguish its importance for testing related to the control building vs. the containment structure?

   Discussion: No tensile strength testing is being performed on the concrete core samples and this question was raised in the RAI request for information 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 ASR pressure load is transferred to the rebar. Available research in this area appears to be conflicting. For example, using ASTM standards, the reported tensile values can vary from real values by up to ±40% and, as one researcher said, "...can hardly be assumed to be a material property[1]." Prior to transfer, the pressure contribution appears to be minimal (on the order of less than 5% of the rebar yield based on preliminary research of literature). Other papers including the UFSAR for containment assume concrete in reinforced systems provide no tensile strength. Considerable research may be needed in order to independent establish a regulatory or other basis in this area.

   1."Review of the splitting-test standards from a fracture mechanics point of view", C. Rocco, G. V. Guinea, J. Planas, and M.Elices[b] Facultad de Ingeniería, Universidad Nacional de la Plata, La Plata, Argentina, Departamento de Ciencia de Materiales, Universidad Politécnica de Madrid, Madrid, Spain, 5 September 2000

3. What is the importance of obtaining key parameter test data by conducting confined (tri-axial) core testing?

   Discussion: 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.

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

   Discussion: 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.

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

   Discussion: While this is an issue raised in the attachment, 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. This leads to the next set of questions.

6. What is the complete set of laboratory tests for core sampling including appropriate parameters obtained along with laboratory test conditions?

   Discussion: 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.

7. What is the effect of the alkali-silica reaction degradation on the current and future ability of the control building to respond to design basis loads, including seismic events?

   Discussion: NextEra is planning new modeling of the building loads including seismic. A review of the seismic analysis codes is beyond the current capability of the Region I technical staff. This review should include an assessment of the need to analyze the foundations alone vs. the response of a whole structure when just the foundation is degraded.

<u>Coordination</u>

This request was discussed between Richard Conte and his staff and Meena Khanna and her staff along with Barry Miller (NRR) during a final conference call on ..... . The TIA was accepted with an agreed upon preliminary draft response date within 45 days so that Region I can communicate staff concerns to NextEra, if any. A final response would be dependent on one of two situations:

1) If NextEra performs the final operability determinations as scheduled for September 30, 2011, NRR would hold the TIA in abeyance pending a review for adequacy of any applicable final operability determination documentation in light of the issues noted herein to no later than 60 days from NRR receipt of the final operability determinations and realted supporting information; or,

2) If NextEra is delayed in conducting the final operability determinations as scheduled for September 30, 2011, assist the region in evaluating the need for the delay and address the adequacy of reasons for the delay and a review of the Control Building POD and related open issues in a final response in 90 days from the date of this TIA.

References

http://ims.certrec.com

(No. 2 on Certrec Document Library Tab List) C-S-1-10159 CALC_000, Rev. 0, 'B' Electrical Tunnel Transverse Shear Evaluation Supplement to Calculation CD-20

(No. 4 on Certrec Document Library Tab List) C-S-1-10150 CALC_000, Rev. 0, Effects of Reduce Modulus of Elasticity – 'B' Electrical Tunnel Exterior Walls

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(No. 6 on Certrec Document Library Tab List) Action Request (AR) 581434 Prompt Operability Determination Reduced Concrete Properties Below Grade in 'B' Electrical Tunnel Exterior Walls.

http://portal.nrc.gov/edo/ri/EB1/Shared%20Documents/Forms/AllItems.aspx

Docket No. 50-443

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Attachment

DE/EMCB Comments on AR1644074 Evaluation of Containment Enclosure Building (CEB) (4-27-11)

1. An important effect of reduction in elastic modulus (Ec) of concrete due to ASR is a reduction in stiffness (axial, flexural, shear) of the affected areas relative to the stiffness of the unaffected areas. This would result in redistribution of forces in the global response of the structure under design loads due to changes in the relative stiffness of the affected and unaffected areas from that considered in the original global structural analyses of the CEB using the SAG computer code. Further, since the ASR degradation is in the lower areas of the CEB, the reduction in elastic modulus could affect the boundary conditions assumed in the original analysis at the junction of the basemat and the CEB wall. Note that FSAR Section 3.8.4.4.a states, in part, that *"Lateral forces are transferred to the foundation mats primarily by the action of shear walls; some load is also transferred by means of flexural action of the wall, all of which are rigidly attached at the mat."* Also refer to pages 11 and 12 of Calculation C-S-1-10150. The AR1644074 Evaluation does not address the effect of the reduced modulus on the global response of the structure. It assumes that the forces and moments in the different elements of the structure under design loads remains the same and only evaluates the local sections (concrete stresses, strains and flexural capacity) for the reduced modulus, which are based on forces and moments from the original structural analysis.

2. The AR1644074 Evaluation does not evaluate the effect of the reduced modulus on the shear capacity of the affected area.

3. The AR1644074 Evaluation does not address the effect of the reduced modulus on the potential changes in the natural frequencies of the CEB structure, which could have effect the response of the structure to seismic load.

4. The AR1644074 Evaluation of the local section does not evaluate the effect of reduced modulus on stress and strain in the rebar. The strain in the rebar could go beyond the yield strain. From page 47 of Calc CE-4 referenced in the evaluation for element 255, the stress in the hoop reinforcement is 61.493 ksi, which is already beyond yield.

5. The AR1644074 Evaluation of the local section is based on element 255, which is 27" thick and appears to be outside the area affected by ASR. The areas affected by ASR appear to be at the lower elevations of the CEB which are 36" thick. A critical element in the affected area needs to be evaluated. Further, note that the forces and moments in element 255 could increase based on Comment 1 above, and thereby further affect concrete and rebar stresses and strains in element 255.

6. The AR1644074 Evaluation does not explicitly evaluate the effect of the reduced modulus on the flexural capacity of affected local sections, but makes reference to Calc

C-S-1-10150 performed for the electrical tunnel. The effect on flexural capacity of the affected Section of the CEB should be explicitly evaluated since the effect of the reduced modulus on moment capacity of a section is a function of the amount of reinforcement in the section, the section dimensions and material properties. The CEB wall reinforcement, dimensions and material properties appear significantly different from that of the electrical tunnel.

7. ~~On page 2 of the AR1644074 Evaluation, it is stated that "The reduction in Ec causes the neutral axis of the balanced concrete and reinforcing steel section to shift toward the tension reinforcing steel." It appears that the reduction in Ec would tend to cause the neutral axis to shift toward the extreme compression fiber that the tension reinforcing steel per T~~
   Per George Thomas telecon of June 9, 2010 with R. Conte.

8. To have any level of statistical validity, the number of cores used in an evaluation should be at least 3. The AR1644074 Evaluation uses results based on only 2 core tests of the ASR affected area.

9. What are the strain levels at the reported values of concrete compressive strength and elastic modulus from core tests reported in Table 1 of AR1644074? Does petrographic examination of the cores indicate ASR through the thickness of the wall.

10. The AR1644074 evaluation should include a problem statement description of the condition being evaluated and its preliminary extent (at least based on visual inspection) for the structure in question so that an outside reviewer can understand what is being evaluated.