



UNITED STATES
NUCLEAR REGULATORY COMMISSION

REGION I
475 Allendale Road
King of Prussia, PA 19406

*Draft from Region I
GT & DHS Comment*

MEMORANDUM TO: John Jolicoeur, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

FROM: Darrell J. Roberts, 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 consequence structural effects and management of alkali-silica reaction (ASR) degradation of safety related concrete structures at Seabrook Station, and to evaluate the impact of the degradation on the current licensing and design basis.

Background

NextEra analyzed concrete core samples from the interior surface of exterior walls of the Control Building as part of their material condition assessment of concrete structures 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 alkali-silica-reaction (ASR) in core samples taken from chronically wet walls below grade, with apparent reductions reported in the concrete compressive strength and modulus of elasticity. NextEra evaluated these parametric reductions to determine the impact on the design basis of the Control Building. The licensee performed an operability determination and concluded the Control Building was within the limits of the design basis although with reduced margins. NextEra continues to evaluate the extent of this condition.

NextEra's planned actions 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. Their proposal is described in their letter of April 14, 2011, in response to an NRC request for additional information B.2.1.31-1(ML11008A131). The proposal includes another (termed "final" by NextEra) analysis of the impact of ASR on the current licensing and design basis, including the an extent of the condition assessment of ASR to support the prompt operability determination, to be completed during June 2011.

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Comment [G1]: Please identify the specific structures under the scope of this TIA for which approved licensee evaluations would be available for review in the near future.

Comment [G2]: Please include a statement of how the degraded condition was first identified and what led to the core samples being taken.

Comment [G3]: Please specify reduction is relative to what? Specified 28-day design strength/modulus? 28-day test results? or current test results from an unaffected area?

Comment [G4]: ?? "strength reserves to design capacity" is the more appropriate phrase when you are referring to reserves between demand under loads and capacity, due to conservative design. Margin (or safety factors) for structures in the regulatory sense and code sense means the safety margin between the reliable design capacity or allowable (per code) and the ultimate capacity at which a structure is on the verge of collapse. Safety margins or factors are provided for in the code design philosophy to account for uncertainties (unknowns in analysis, unknowns in design, under-strength, over-loads etc.). You cannot have reduced margins and meet design basis.

Predecisional - 11/2/12

F/1

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 (m!ML111330689). More details related to the newly discovered ASR issue is also documented in NRC Inspection Report No. 05000443/2011007 (m!ML111360432) as a part of the license renewal inspection report. The cover letter for this 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 working closely together to ensure the agency reviews this matter in unison.

June 2011. In a review of the final analysis, Region I needs requests the assistance of NRR in reviewing various NextEra documents/evaluations to be issued from now until March 2012 (tentative) as noted in the licensee's position section below.

Licensee Position

NextEra has conducted a number of evaluations of ASR affected structures. Their actions are centered around taking core samples of the concrete and conducting various tests for compressive strength and modulus of elasticity on those unconfined samples. The primary actions to date or planned are:

1. Preliminary Prompt Operability Determination for the Control Building (AR 581434 available by "certrec" website) based on compressive strength and modulus of elasticity testing. Petrographic examination was also conducted confirming the presence of ASR in the core samples.
2. Design Change No. EC-272057, Concrete Modulus of Elasticity for the Control Building Electrical Tunnel and the Containment Enclosure Building (available by certrec website), referring to AR Nos. 581434 and AR 1644074 which accepts the reduction in the modulus of elasticity in light of concrete core testing using a 10 CFR 50.59 screening process.
3. Additional core sampling on five other buildings with less severe evidence of ASR – Operability Determination will be available on or about June 30, 2011.
- 2.4. Engineering Evaluation scheduled for March 2012 which completes the aging management review and it is anticipated that it will not only address the proposed aging management program for license renewal but also provide recommended changes in the current Structures Monitoring Program for all Maintenance Rule in-scope building affected by ASR.

Within the limitations of their testing, NextEra's testing to date has not resulted in seismic category I structures being outside their design basis (control building and containment enclosure building).

Comment [G5]: What is the licensee's plan of action to address the ASR issue for the period of the current operating license?

Comment [G6]: This is vague and open ended. TIAs are meant to address specific technical questions.

Comment [G7]: Please include the licensee's detailed overall plan of action to systematically address the ASR degradation issue in its entirety (including process used, condition survey, condition assessment (extent and characterization including inaccessible areas that may be affected), root cause evaluation, determination of structure severity rating (including quantified expansion-to-date and potential future expansion and considering structure reinforcing class and exposure conditions), structural evaluation and appraisal of degraded condition for design loads, and determining remedial action/ condition management, as appropriate) in the current operating license period. The licensee's actions of taking core samples and conducting selective tests should be justified into the context of the overall plan. This plan should clearly bring out the licensee's philosophy and thinking for addressing the ASR degradation issue, in its entirety, and how the items listed in the licensee position fits into the context of the plan. The licensee's plan and evaluation should factor in a quantitative manner how the ability of the affected structures to perform the intended function and meet their design basis will be impacted if the ASR degradation continues into the future.

Comment [G8]: The ASR affected/suspected structures should be specifically identified by the licensee and listed here by name, as described in the FSAR.

Comment [G9]: Justify why just testing for compressive strength and elastic modulus is sufficient. Why not tensile strength, poisson ration, stiffness damage tests etc?

Comment [G10]: Suggest delete. What is the point being made here? There is no standard protocol in concrete technology to take and test cores or test cylinders other than the way it is removed or the way the cylinders are cast.

Comment [G11]: What is the technical basis of this approach? It appears that the licensee's thinking is that the entire ASR issue can be addressed by testing cores for compressive strength and modulus of elasticity and that the behavior of the degraded concrete remains unaffected as considered in the codes. The approach does not appear to address the ASR degradation issue in its entirety (diagnosis ... [1])

Comment [G12]: Need to be specific.

Comment [G13]: How about factors and considerations not covered by the testing (such as cause of the degradation, degradation into the future, shear, etc)?

Region I Preliminary Inspector Views/Observations

Based on staff interactions to date related to this issue a number of questions have arisen:

1. Because the original design basis assumes no ASR is present during the design life of the structure, it is not clear how ASR affects the original design assumptions or calculational methods, such as the relationship between compressive strength and modulus of elasticity to shear capacity and shear distribution of design forces used in the seismic analysis. For example the assumed relationship between compressive strength and tensile strength, shear strength, elastic modulus etc may not be valid with ASR present. We agree with headquarter staff who have raised a questions in this area. What remains unknown is how much of an effect does the ASR have on this validity (some research may be needed).
2. A preliminary analysis by NextEra focuses on the effect of ASR on the foundation's response to design loads. It is not clear this approach, in the final analysis, would be adequate. Should we Region I insist the final analysis include the response of the whole building with ASR present in the foundation?
3. What is the extent, duration, and timing of actions that NextEra should take to address the problem of immediate operability, and maintenance of the design basis response? In other words, how long do we wait and under what criteria do we have for research to be developed in order to address key questions related to operability and compliance with the current licensing and design basis.
4. It should be noted that no tensile strength testing is being performed on the concrete core samples and it is as an issue raised by headquarters staff. With respect to the question of tensile strength reduction in concrete, the inspector's view is that it is not relevant in a constrained structure after the ASR pressure load is transferred to the rebar. Using the ASTM standard proposed by NRR, the tensile values reported can vary from the real values by up to $\pm 40\%$ and, as one researcher said, "...it 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).
5. A core sample with ASR does not represent the forces contained in the structure because for this test, in particular, rebound is not considered and frictional influences in the test itself are not accommodated. As a matter of fact the frictional losses are 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.
6. Preliminarily the design change had a 50.59 review which screened out. In light of the newly discovered issue, one would think that, as a minimum, an evaluation would have been conducted in order to determine if there is an unreviewed safety question.

1. "Review of the splitting test standards from a fracture mechanics point of view", C. Rocco, G. V. Guinea, J. Planas, and M. Elices, 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

NextEra's testing to date has not resulted in seismic category I structures being outside their design basis (control building and containment enclosure building).

Comment [G14]: Licensee needs to demonstrate the validity and submit to NRC.

Comment [G15]: Need to be specific about the structure and foundation being referred to and their configuration and the condition that is being evaluated.

Comment [G16]: For answers to these questions, the Region needs to consult NRC Inspection Manual Part 9900: Technical Guidance – Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety. Suggest review entire guidance and specific attention be drawn to Section 4.0 (Operability Determination Process) and Section C.13 (Specific Operability Issues – Structural Requirements).

Comment [AHS17]:

Copy of relevant section of the ASTM 496

10. Precision and Bias

10.1 Precision—An inter laboratory study of this test method has not been performed. Available research data,³ however, suggests that the within batch coefficient of variation is 5 % (see **Note 4**) for 6 3/12-in. [150 3/300-mm] cylindrical specimens with an average splitting tensile strength of 405 psi [2.8 MPa]. Results of two properly conducted tests on the same material, therefore, should not differ by more than 14 % (see **Note 4**) of their average for splitting tensile strengths of about 400 psi [2.8 MPa].

Also I do not understand relationship between rebar yield strength and concrete shear/tensile strength as stated here.

Comment [G18]: Suggest delete since this is speculative discussion. FYI - The conditions under which cracks form and propagate in concrete depend strongly on tension strength. Concrete tensile stresses also occur as a result of shear, torsion and other actions, and in most cases member behavior changes upon cracking. Hence, it is important to be able to measure or predict with reasonable accuracy the tensile strength of concrete. It is important to realize that the real concern in shear analysis and design is with diagonal tension stress ... [2]

Comment [G19]: Suggest delete. FYI - Note that direct and split tensile strength tests (~15 each) were successfully conducted on cores at Crystal River as part of the root cause investigation of the recent containment delamination issue. The delamination occurred in a concrete with lower than normal tensile strength and limited crack arresting capability.

Comment [AHS20]: This whole statement is redundant and not relevant. Please delete it.

Comment [G21]: The current 50.59 rule (effective 2000) has removed the term "unreviewed safety question" from the regulations and instead refer to the need to obtain a license amendment. Suggest, revise the language to be consistent with the current regulations.

Requested Actions

In light of the questions above, Region I needs requests the assistance of NRR/DE in conjunction with the Division of License Renewal and as applicable the Office of Research in order to evaluate the below listed following areas for the above noted NextEra operability determination and design changes or other evaluations that may support these reviews such as detailed calculations or computer code work. For each of the area, our regulatory basis should be clearly identified:

Comment [G22]: ??

1. Adequacy of concrete core sampling (locations, numbers, frequency of sampling in the future, etc).
2. Completeness of the laboratory testing of core sampling including appropriate parameters obtained along with laboratory test conditions for now and in the future.
3. Need for and cCompleteness of any insitu the-testing of building conditions core-sample including appropriate parameters obtained along with test conditions for now and in the future. As an example, where and how much rebar should be exposed in order to assess the effect on rebar from the ASR issue.
4. Assess the effect of the alkali-silica reaction degradation on the current and future ability of safety structures to respond to design basis loads including seismic response.
5. Adequacy of an analysis of the foundations alone vs. the response of the whole structure when the foundation is degraded.
- 5-6. From the analysis done above, review the adequacy of the structures monitoring program for necessary changes in light of the ASR issue.
6. Adequacy of the NextEra initial prompt operability determination of the control building.
7. Adequacy of the NextEra final operability determination completed during June 2011.

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In the longer term on or about March 2012, Region I needs the same assistance as noted above when NextEra completes and Engineering Evaluation which should complete the aging management review for license renewal but more importantly, recommendations are anticipated with respect to changes to the existing structures monitoring program to meet the maintenance rule up to the license expiration date, to be completed during March 2012. We request NRR review for adequacy of the additional monitoring and mitigation strategies proposed by NextEra in light of the newly discovered ASR issue.

Comment [G23]: Questions for NRR to address should be specific with reference to work the licensee has completed and documented and should relate to the context of the overall action plan to address the ASR issue. Suggest issue the initial TIA based on a well considered documented licensee action plan and specific questions based on documents of completed evaluations that are currently available or will be available in the very near future. Then, issue subsequent separate TIAs or revised TIAs with questions to be addressed as more licensee evaluations are completed in the context of the overall plan.

Coordination

This request was discussed between Richard Conte (RI/DRS/EB1) and Meena Khanna (NRR/DE/EMCB) during a various conference calls on the subject of ASR at Seabrook. The TIA was accepted with an agreed upon response date within 90 days after receipt of the NextEra Engineering Evaluation completed during March 2012.

Comment [G24]: 120 days for draft and 180 days for final response?

References

Comment [G25]: References should be specific and explicitly listed, although they may be placed and accessed from the website.

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

Docket No. 50-443

ML111610530

SUNSI Review _____ Complete

DOCUMENT NAME: G:\DRS\Engineering Branch 1\-- MModes\TIA Seabrook ASR Draft 2.docx

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Page 2: [1] Comment [G11]

GThomas

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What is the technical basis of this approach? It appears that the licensee's thinking is that the entire ASR issue can be addressed by testing cores for compressive strength and modulus of elasticity and that the behavior of the degraded concrete remains unaffected as considered in the codes. The approach does not appear to address the ASR degradation issue in its entirety (diagnosis, prognosis, structural appraisal and evaluation, and mitigation/management). Has the licensee consulted specialist literature and personal in the area of ASR?

Page 3: [2] Comment [G18]

GXT4

6/27/2011 2:18:00 PM

Suggest delete since this is speculative discussion. FYI - The conditions under which cracks form and propagate in concrete depend strongly on tension strength. Concrete tensile stresses also occur as a result of shear, torsion and other actions, and in most cases member behavior changes upon cracking. Hence, it is important to be able to measure or predict with reasonable accuracy the tensile strength of concrete. It is important to realize that the real concern in shear analysis and design is with diagonal tension stress (areas of high shear in combination with flexure could fail suddenly by developing diagonal cracks and therefore many ACI codes refer to shear as a measure of diagonal tension). Relationships in the ACI codes that are a function of $\sqrt{f_c'}$ are indeed a function of concrete tensile strength.