Enclosure 5 to this Letter Contains ~~Proprietary Information~~
~~Withhold Enclosure 5 from Public Disclosure in Accordance with 10 CFR 2.390~~

NEXTera® ENERGY SEABROOK

December 23, 2016
10 CFR 54

SBK-L-16181
Docket No. 50-443

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Seabrook Station

Seabrook Station, License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program

References:

1. NextEra Energy Seabrook, LLC letter SBK-L-10077, "Seabrook Station Application for Renewed Operating License," May 25, 2010. (Accession Number ML101590099)
2. U.S. Nuclear Regulatory Commission Public Meeting Summary, Public Meeting with NextEra Energy Seabrook, LLC Regarding Aging Management of Alkali-Silica Reaction Pertaining to the License Renewal of Seabrook Station, Unit 1. April 28, 2016. (Accession Number ML16146A176)
3. NextEra Energy Seabrook, LLC letter SBK-L-16013, "Seabrook Station, License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program," August 9, 2016. (Accession Number ML16224B079)
4. U.S. Nuclear Regulatory Commission, Requests For Additional Information for the Review of the Seabrook Station License Renewal Application (CAC NO. ME4028). December 12, 2016. (Accession Number ML16326A037)

In Reference 1, NextEra Energy Seabrook, LLC (NextEra Energy Seabrook) submitted an application for a renewed facility operating license for Seabrook Station Unit 1 in accordance with the Code of Federal Regulations, Title 10, Parts 50, 51, and 54.

In Reference 3, NextEra Energy Seabrook provided additional clarifying information as discussed with the staff during a public meeting on April 28, 2016 (Reference 2). Following this submittal the staff conducted an Audit of Seabrook's ASR and Building Deformation Aging Management Programs. During the exit debrief the staff identified several areas within the submitted Aging Management Programs that needed clarification and enhancement.

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In Reference 4 the staff provided RAIs related to items identified during the Audit. Enclosure 5 provides a response to these RAIs and a general discussion of the changes to clarify and enhance the previously submitted Aging Management Programs. Portions of Enclosure 5 are considered proprietary to NextEra Energy Seabrook and are designated with red brackets. Enclosure 1 provides a redacted nonproprietary version of this response.

Enclosure 2 provides a revised LRA Appendix A - Updated Final Safety Analysis Report Sections A.2.1.31 for Structures Monitoring, A.2.1.31A for Alkali-Silica Reaction and A.2.1.31B for Building Deformation. Enclosure 3 provides a revised LRA Appendix B Sections B.2.1.31 for Structures Monitoring, B.2.1.31A for Alkali-Silica Reaction (ASR) and B.2.1.31B for Building Deformation Aging Management Programs. To facilitate understanding, the changes are explained, and where appropriate, portions of the LRA are repeated with the change highlighted by strikethroughs for deleted text and bolded italics for inserted text. These two revisions supersede the respective previously submitted sections to the LRA.

This letter contains two new Commitments (45 and 66) and two revised Commitments (83 and 91). Enclosure 4 provides the revised LRA Appendix A - Updated Final Safety Analysis Report Supplement Table A.3, License Renewal Commitment List.

This letter is supported by an affidavit signed by NextEra Energy Seabrook (Enclosure 6), setting forth the basis on which the information in Enclosure 5 may be withheld from public disclosure by the Commission and addressing the considerations listed in 10 CFR 2.390(b)(4). Accordingly, it is respectfully requested that the information which is proprietary be withheld from public disclosure in accordance with 10 CFR 2.390.

If there are any questions or additional information is needed, please contact Mr. Edward J. Carley, Engineering Supervisor - License Renewal, at (603) 773-7957.

If you have any questions regarding this correspondence, please contact Mr. Ken Browne Licensing Manager, at (603) 773-7932.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 23, 2016

Sincerely,

Eric McCartney
Site Vice President
NextEra Energy Seabrook, LLC

Enclosures:

Enclosure 1 - Enclosure 1 - Seabrook Station License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program for the Seabrook Station License Renewal Application Clarifying Information and Response to Requests for Additional Information (Nonproprietary)

Enclosure 2 -Seabrook Station Updated Final Safety Analysis Report Section A.2.1.31 for Structures Monitoring, Section A.2.1.31A for Alkali-Silica Reaction and Section A.2.1.31B for Building Deformation

Enclosure 3 -Seabrook Station License Renewal Application Section B.2.1.31 for Structures Monitoring, Section B.2.1.31A for Alkali-Silica Reaction and Section B.2.1.31B for Building Deformation Aging Monitoring Programs

Enclosure 4 -LRA Appendix A - Final Safety Report Supplement Table A.3, License Renewal Commitment List Updated to Reflect Changes to Date.

Enclosure 5 -Seabrook Station License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program for the Seabrook Station License Renewal Application Clarifying Information and Response to Requests for Additional Information (Proprietary)

Enclosure 6 - NextEra Energy Seabrook, Application for Withholding Proprietary Information from Public Disclosure and Affidavit

cc:	D. H. Dorman	NRC Region I Administrator
	J. C. Poole	NRC Project Manager
	P. C. Cataldo	NRC Senior Resident Inspector
	T. M. Tran	NRC Project Manager, License Renewal
	L. M. James	NRC Project Manager, License Renewal

Mr. Perry Plummer
Director Homeland Security and Emergency Management
New Hampshire Department of Safety
Division of Homeland Security and Emergency Management
Bureau of Emergency Management
33 Hazen Drive
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Mr. John Giarrusso, Jr., Nuclear Preparedness Manager
The Commonwealth of Massachusetts
Emergency Management Agency
400 Worcester Road
Framingham, MA 01702-5399

Enclosure 6 to SBK-L-16181

NextEra Energy Seabrook LLC: Application for Withholding Proprietary Information from Public Disclosure

Affidavit in Support of Application for Withholding Proprietary Information from Public Disclosure

NextEra Energy Seabrook, LLC

AFFIDAVIT IN SUPPORT OF APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

County of Rockingham)
)
State of New Hampshire)

I, Eric McCartney, being duly sworn according to law, depose and state the following:

(1) I am the Site Vice President of NextEra Energy Seabrook, LLC (NextEra Energy Seabrook), and have been delegated the function of reviewing the information described in paragraph (3) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) I am making this Affidavit in conjunction with NextEra Energy Seabrook's "Application for Withholding Proprietary Information from Public Disclosure" accompanying this Affidavit and in conformance with the provisions of 10 CFR Section 2.390.

(3) The information sought to be withheld is contained in Enclosure 5 of NextEra Energy Seabrook's letter SBK-L-16181, Eric McCartney (NextEra Energy Seabrook) to U.S. Nuclear Regulatory Commission, entitled "Seabrook Station, License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program."

(4) The information sought to be withheld is considered to be proprietary and confidential commercial information because alkali-silica reaction (ASR) is a newly-identified phenomenon at domestic nuclear plants. The information requested to be withheld is the result of several years of intensive NextEra Energy Seabrook effort and the expenditure of a considerable sum of money. This information may be marketable in the event nuclear facilities or other regulated facilities identify the presence of ASR. In order for potential customers to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent

and experience, would have to be expended. The extent to which this information is available to potential customers diminishes NextEra Energy Seabrook's ability to sell products and services involving the use of the information. Thus, public disclosure of the information sought to be withheld is likely to cause substantial harm to NextEra Energy Seabrook's competitive position and NextEra Energy Seabrook has a rational basis for considering this information to be confidential commercial information.

(5) The information sought to be withheld is being submitted to the NRC in confidence.

(6) The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by NextEra Energy Seabrook, has not been disclosed publicly, and not been made available in public sources.

(7) The information is of a sort customarily held in confidence by NextEra Energy Seabrook, and is in fact so held.

(8) All disclosures to third parties, including any required transmittals to the NRC, have been or will be pursuant to regulatory provisions and/or confidentiality agreements that provide for maintaining the information in confidence.

I declare that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief. Further, the affiant sayeth not.

Eric McCartney
Site Vice President
NextEra Energy Seabrook, LLC
626 Lafayette Road
Seabrook, New Hampshire 03874

Subscribed and sworn to before me
this 23 day of December, 2016.

Shirley Sweeney
Notary Public
My commission expires January 14, 2020

SHIRLEY SWEENEY
MY COMMISSION EXPIRES JAN. 14, 2020
NOTARY PUBLIC
NEW HAMPSHIRE

<u>Enclosure 1 to SBK-L- 16181</u>

Seabrook Station License Renewal Application
Relating to the Alkali-Silica Reaction (ASR) Monitoring Program
for the Seabrook Station License Renewal Application
Clarifying Information and Response to Requests for Additional Information

(Nonproprietary)

NRC staff / NextEra Energy Seabrook staff identified items for correction during October 24 AMP Audit:

1. NextEra Energy Seabrook stated it needed to clarify that for the Building Deformation program, it does not need to start with a "stage 1" evaluation and that the evaluation for each structure can start at any of the three stages (using a general basis), and if necessary progress to higher stages where necessary. NextEra Energy Seabrook stated it will modify the submittal anywhere (i.e., instances in the submittal) that reads as though a structure must be analyzed at a lower stage before conducting an analysis at a higher stage.

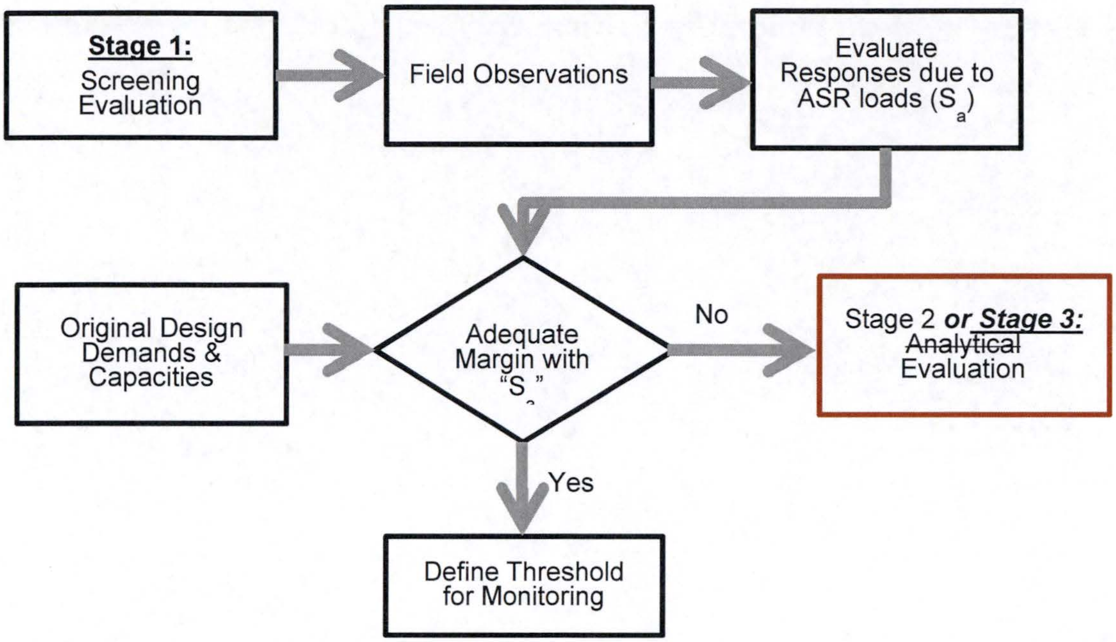
NextEra Energy Seabrook Response

Aging Management Program B.2.1.31.B-*Building Deformation* Element 3-*Parameters Monitored/Inspected* (SBK-L-16013 / Enclosure 4 / Page 22) is revised to a include statement regarding the initial selected analysis stage:

ELEMENT 3 - Parameters Monitored/Inspected

A three ~~step~~ ***stage*** process will be used to initially screen for deformation and to analyze the effects on structures for the self-straining loads from ASR expansion, creep, shrinkage, and swelling. Each stage of the process would have increasing levels of rigor. ***The analysis and evaluation of each structure may begin at any of the three stages. If initial review of a structure determines that a structure cannot be qualified in a particular evaluation stage due to high ASR expansion, low margin in the structural design, or any other limitation that excludes the structure from being qualified at that stage, the structure can be evaluated at a higher stage evaluation that employs more rigor. Ultimately the structure is classified according to the stage in which it is qualified to meet the design code requirements and monitored accordingly. For example, a stage 2 structure is qualified using a stage 2 evaluation and thresholds are monitored to stage 2 thresholds.***

Aging Management Program B.2.1.31.B-*Building Deformation* Element 3-*Parameters Monitored/Inspected* Stage 1: Susceptibility Screening Evaluation (SBK-L-16013 / Enclosure 4 / Page 25) is revised to reflect that a Stage 1 evaluation may progress directly to a Stage 3 Detail Evaluation



2. NRC requested that NextEra Energy Seabrook docket information from its "Criteria Document" to include best practices and improve clarity and consistency of the Stage 1, 2 and 3 evaluation process descriptions in the Building Deformation AMP. Specifically, this includes the verbiage from Chapter 9.1 two sentences starting from the words "Field data that are older than the monitoring interval program..."

NextEra Energy Seabrook Response

Aging Management Program B.2.1.31B-*Building Deformation* Element 3-*Parameters Monitored/Inspected* Stage 1: Susceptibility Screening Evaluation (SBK-L-16013 / Enclosure 4 / Page 24) is revised to include a statement regarding validation of older data.

Stage 1: Susceptibility Screening Evaluation

NextEra Energy Seabrook has conducted walkdowns of selected in scope structures and plant equipment to identify items of interest and evaluate the items through the Corrective Action Program for their impact on plant operations. NextEra Energy Seabrook will perform future walkdowns for all in scope structures. Inspection data from these walkdowns and other measurements obtained for ASR-affected structures will be reviewed to determine if deformation is occurring and to identify potential locations and directions of movement or deformation. The data that will be collected includes measurements of relative building movements, equipment misalignments, and concrete cracking indexes. ASR monitoring grids, which are used to measure the strain in reinforced concrete, were installed on structures throughout the facility. The monitoring grids were installed at the most severe locations for ASR cracking, and therefore, provide a conservative estimate of the strain in the structure. After reviewing existing field data, a walkthrough inspection will be performed to verify field conditions and determine if ASR expansion only affected localized regions of the structure or whether the structure has experienced global deformation of structural members. ***Field data that is older than three years old shall be verified during this walkthrough inspection.***

3. NRC noted that reference to ASME Section XI, Subsection IWL should be added anywhere the AMP mentions the Structures Monitoring Program if Primary Containment is also included in the discussion or the plant-specific ASR AMPs/FSAR supplements.

NextEra Energy Seabrook Response

Seabrook Station Updated Final Safety Analysis Report A.2.1.31A -ALKALI-SILICA REACTION (ASR) MONITORING (SBK-L-16013 / Enclosure 3 / Page 2) is revised as follows:

The ~~Structural~~ ***Structures*** Monitoring Program ***and Section XI Subsection IWL Program*** performs visual inspections of the concrete structures at Seabrook for indications of the presence of alkali-silica reaction (ASR). ASR involves the formation of an alkali-silica gel which expands when it absorbs water. This expansion is volumetric in nature but is most readily detected by visual observation of cracking on the surface of the concrete. This cracking is the result of expansion that is occurring in the in-plane directions. Expansion is also occurring perpendicular (through the thickness of the wall) to the surface of the wall, but cracking will not be visible in this direction from the accessible surface. Cracking on the surface of the concrete is typically accompanied by the presence of moisture and efflorescence. Concrete affected by expansive ASR is typically characterized by a network or "pattern" of cracks. Micro-cracking due to ASR is generated through forces applied by the expanding aggregate particles and/or swelling of the alkali-silica gel within and around the boundaries of reacting aggregate particles. The ASR gel may exude from the crack forming white secondary deposits at the concrete surface. The gel also often causes a dark discoloration of the cement paste surrounding the crack at the concrete surface. If "pattern" or "map" cracking typical of concrete affected by ASR is identified, an evaluation will be performed to determine further actions.

Aging Management Program B.2.1.31.A- Alkali-Silica Reaction under Program Elements (SBK-L-16013 / Enclosure 4 / Page 5) is revised as follows:

ELEMENT 1 - Scope of Program

The Seabrook Station Alkali-Silica Reaction (ASR) Monitoring Program provides for management of aging effects due to the presence of ASR. Program scope includes concrete structures within the scope of the License Renewal Structures Monitoring Program ***and License Renewal ASME Section XI Subsection IWL Program.*** License Renewal concrete structures within the scope of this program include:

Aging Management Program B.2.1.31.B - Building Deformation under Program Elements (SBK-L-16013 / Enclosure 4 / Page 22) is revised as follows:

ELEMENT 1 - Scope of Program

The Seabrook Building Deformation Monitoring Program provides for management of the effect of building deformation on Seismic Category 1 structures and associated components within the scope of license renewal. Program scope includes components within the scope of license renewal contained in concrete structures within the scope of the Structures Monitoring Program ***and License Renewal ASME Section XI Subsection IWL Program.*** Concrete structures within the scope of this program include:

4. Commitment 83

As discussed with the staff NextEra Energy Seabrook is revising the commitment related to the installation of extensometers in Tier 3 locations by 60 days to accommodate current scheduling activities on site.

Commitment 83 is revised as follows:

83	Alkali-Silica Reaction Monitoring	Enhance the ASR AMP to install extensometers in all Tier 3 areas of two dimensional reinforced structures to monitor expansion due to alkali-silica reaction in the out-of-plane direction. Monitoring expansion in the out-of-plane direction will commence upon installation of the extensometers and continue on a six month frequency through the period of extended operation.	A.2.1.31A	~~December 31,2016~~. ***February 28, 2017***

Requests for Additional Information (RAIs)

RAI B.2.1.31A-A1 (PARAMETERS MONITORED OR INSPECTED)

Background

SRP-LR Section A.1.2.3.3 states that the "Parameters Monitored or Inspected" program element should identify the aging effects that the program manages and should provide a link between the parameter or parameters that will be monitored and how the monitoring of these parameters will ensure adequate aging management. The SRP also states that the parameter monitored or inspected should be capable of detecting the presence and extent of aging effects.

In its August 9, 2016, submittal, the applicant stated under the Section B.2.1.31A "Parameters Monitored or Inspected" program element that "initial screening for ASR [expansion] will be performed using [combined cracking index] CCI only and CCI values exceeding 1 mm/m will trigger additional actions." The program also states that the large-scale test program conducted at the University of Texas indicated that direction of expansion is not significantly affected by the reinforcement when expansion is at or below 1 mm/m but that "beyond this level, through-thickness expansion dominates." The staff noted in the "Acceptance Criteria" program element that 1 mm/m is the threshold for "Tier 3" and subject to enhanced ASR monitoring, such as through-wall expansion monitoring using Extensometers. The "Parameters Monitoring or Inspected" program element states that the periodic extensometer measurements of through-thickness expansion is the parameter to be monitored when an ASR location reaches the Tier 3 monitoring criteria.

The August 9, 2016, letter states that CCI is also used to measure the effects of associated rebar strain.

Issue

During its onsite audit the staff reviewed program basis information and reviewed implementation of the ASR Monitoring program to date, including the CCI monitoring at Tier 2 locations and the through-wall extensometer measurements at "Tier 3" locations. The staff noted that the through-wall monitoring acceptance criteria values were based on the large-scale testing program results, and that the tests considered volumetric expansion (i.e. in the horizontal, vertical, and through-wall directions), and not just the through-wall expansion. From the staff's review of the program, it is not clear to the staff whether the program considers the volumetric expansion, and whether strain in the horizontal and vertical directions is monitored, once a location is placed into the "Tier 3" category. Further, the staff noted that (a) the applicant has completed some of its core testing from Seabrook structure locations for installation of extensometers and (b) there have been variations in crack distribution depending on the location of the core such that in-plane strain may not be "insignificant" compared to out-of-plane expansion, contrary to the applicant's claim. From its review of the "Acceptance Criteria" program element, the staff noted that acceptance criteria for volumetric expansion did not appear to be included.

In addition, it is not clear how the program explicitly uses CCI to "measure the effects of rebar strain due to ASR expansion" as is stated in the August 9, 2016 submittal.

Request

1. Considering (a) variations in boundary conditions of Seabrook structures compared to large-scale test beams and (b) results of plant-specific information regarding in-plane vs. out-of-plane expansion-to-date of concrete cores taken at Seabrook, state whether additional parameters such as volumetric expansion will be monitored such that ASR expansion effects are captured in their totality; or provide additional information supporting the use of through-wall monitoring as the only monitoring parameter for "Tier 3" ASR locations. If volumetric expansion will be monitored, explain how this will be accomplished.
2. State how the program will use CCI to manage ASR-induced rebar strains and stresses such that they remain within design code limits, by the ASR-induced strains alone and in combination with design basis loads and load combinations, during the period of extended operation.

NextEra Energy Seabrook Response to RAI B.2.1.31A-A1 (Parameters Monitored or Inspected)

NextEra Energy Seabrook Response to Request #1

Summary

As part of routine expansion monitoring as detailed in B.2.1.31A - ALKALI-SILICA REACTION Element 4, NextEra Energy Seabrook will monitor both in-plane and through-thickness expansion of all two dimensional reinforced Tier 3 locations. The AMP requires that extensometers be installed at two dimensional reinforced Tier 3 locations to monitor through-thickness expansion. This is in addition to, not in place of, monitoring of in-plane expansion that commences prior to reaching Tier 3.

NextEra Energy Seabrook will use the in-plane and through-thickness measurements to determine volumetric expansion. Comparison of the calculated volumetric expansion at Seabrook to the calculated volumetric expansion of the test specimens from the large scale test programs will provide additional assurance that the results of the test programs are applicable to ASR-affected concrete structures at Seabrook Station.

The volumetric expansion criterion has been incorporated into Element 10 of Aging Management Program B.2.1.31.A- Alkali-Silica Reaction. Element 6 of Aging Management Program B.2.1.31.A has been revised to clarify that monitoring of Tier 3 locations includes both in-plane expansion (CCI) and through-thickness expansion (extensometers).

Technical Basis

ASR expansion is a volumetric phenomenon in that expansion occurs in all directions. During the large scale test programs, the laboratory monitored in-plane expansion and through-thickness expansion. The Shear Test Program and the Reinforced Anchorage Test Program used through-thickness expansion as the parameter representing ASR degradation because in-plane expansion plateaued at relatively low levels. The Anchor Test Program used in-plane expansion as the parameter representing ASR degradation because the through-thickness expansion does not impact anchor capacity.

The acceptance criteria in the Seabrook ASR AMP reflect the limits from the test programs. The through-thickness expansion limit determined from the shear and reinforcement anchorage test programs and the in-plane expansion limit determined from the anchor capacity test program create an acceptability envelope for measurements at Seabrook. Figure 1 illustrates this envelope.

Figure 1. Limits from Large-Scale Test Programs

NextEra Energy Seabrook is currently implementing in-plane and through-thickness monitoring at Seabrook Station. All Tier 3 locations are monitored for both in-plane and through-thickness expansion. A small number of these locations exhibit in-plane expansion that exceeds the [redacted] mm/m to [redacted] mm/m plateau observed in the large scale test programs. To account for this difference, NextEra Energy Seabrook will monitor volumetric expansion and confirm that ASR expansion is within the volumetric expansion criterion determined from the test programs.

Volumetric expansion can be determined by adding the observed strain in each of the three directions. The equation for combining CCI and through-thickness expansion can be written as follows:

$$\varepsilon_v = 2 \times (0.1 \times CCI) + \varepsilon_{TT}$$

Where:

ε_v = volumetric strain, %
CCI = combined cracking index, mm/m
ε_{TT} = through-thickness expansion, %

Using this equation, the acceptance envelope from Figure 1 can be adjusted to include an acceptance criterion that reflects the volumetric expansion observed in the Shear and Reinforcement Anchorage Test Programs. This acceptance criterion provides additional assurance of the representativeness of the test specimens.

For the FSEL test specimens, the maximum volumetric expansion of a shear test specimen was [redacted]% and the maximum volumetric expansion of a reinforcement anchorage specimen was [redacted]%. Accordingly, NextEra Energy Seabrook has adopted a volumetric expansion acceptance criterion of [redacted]% for observed volumetric expansion at Seabrook Station. Application of this check criterion results in a more conservative acceptability envelope, as shown in Figure 2.

Figure 2. Test Program Limits and Volumetric Expansion Criterion

NextEra Energy Seabrook notes that the results of the test programs demonstrated that there was no adverse effect on structural performance at the maximum expansion observed in the test specimens. Such adverse impact would be exhibited at a greater (potentially much greater) expansion level. Therefore, the test results already include conservatism. Application of the volumetric expansion acceptance criterion provides even more conservatism to the monitoring approach.

An initial expansion assessment of locations with extensometers concluded that expansion at Seabrook has considerable margin to the volumetric expansion limit. The highest calculated volumetric expansion at Seabrook thus far is well below the acceptance criterion determined from the test program.

Consistent with the approach for the in-plane and through-thickness monitoring criteria, any results that exceed the volumetric expansion acceptance criterion would be evaluated under the Seabrook Corrective Action Program (i.e., Element 7 of the AMP).

NextEra Energy Seabrook Response to Request #2

ASR expansion of reinforced concrete produces a displacement-limited chemical prestress. That is, ASR expansion results in tensile strain of the embedded steel reinforcement, while placing the concrete in compression. This prestressing effect was observed in the MPR/FSEL large-scale test programs, and is the reason that there was no adverse effect of ASR on shear capacity, flexural capacity or reinforcement anchorage. However, the effects of the chemical prestress on rebar stress and the additional compressive load on the concrete must be evaluated.

NextEra Energy Seabrook is managing ASR-induced rebar strains and stresses through the combination of structural evaluation and monitoring as defined in the Building Deformation AMP. NextEra Energy Seabrook is currently evaluating the impact of ASR expansion on ASR-affected structures at Seabrook Station. The evaluations consider design loads (including external events such as seismic and wind) in combination with ASR-induced loads. The ASR-induced loads include prestressing from ASR expansion and additional stresses due to the restraint of ASR-affected elements (or areas) by unaffected elements (or areas). Rebar stresses and strains are evaluated relative to the applicable design code. The evaluations define the parameters to monitor and acceptance criteria to ensure that the structure remains bounded by the evaluation. If monitoring shows that a parameter exceeds or will exceed the acceptance criteria, the analysis will be updated to ensure compliance with the design code (including rebar strain provisions) is maintained.

ASR expansion is a key input to the evaluations and therefore a parameter that is monitored. The analyses are based on expansion levels that bound those currently observed in the structure to provide margin for future expansion. NextEra Energy Seabrook currently determines in-plane expansion by measuring the cracking index in both in-plane directions (e.g., horizontal and vertical directions for a wall).[1] The cracking index is the summation of crack widths over a fixed length divided by the fixed length. The MPR/FSEL large-scale test programs demonstrated that cracking index measurements provide a reasonable approximation of the total strain in the concrete and the embedded reinforcement in the in-plane directions after crack initiation.

RAI B.2.1.31A-A2 (DETECTION OF AGING EFFECTS)

Background

SRP-LR Section A.1.2.3.4 states that the "Detection of Aging Effects" program element should describe "when," "where," and "how" program data are collected (i.e., all aspects of activities to collect data as part of the program).

Issue

The "Detection of Aging Effects" program element in the revised LRA Section B.2.1.31A of the August 9, 2016, submittal (including "Out-of-Plane Expansion" and "Snap-Ring Borehole

[1] NextEra typically reports the Combined Cracking Index (CCI) which is the average of the cracking index in the two orthogonal in-plane directions. However, the structural evaluations consider the individual directions to account for any differences between the two directions.

Extensometers" sections) does not specify the inspection interval planned for monitoring through-wall expansion using snap-ring borehole extensometers.

Request

Regarding the use of snap-ring borehole extensometers, clarify the methods and frequencies of inspection(s) for "Tier 3" monitoring locations and update the AMP as necessary.

NextEra Energy Seabrook Response to RAI B.2.1.31A-A2 (Detection of Aging Effects)

Aging Management Program B.2.1.31.A- Alkali-Silica Reaction, Element 4- *Detection of Aging Effects* Sub Section *Snap-Ring Borehole Extensometers* (SBK-L-16013 / Enclosure 4 / Page 14) is revised as follows:

> A SRBE will be installed in a core bore at each Tier 3 location. The elastic modulus will only be determined at the time of core removal to determine pre-instrument expansion to date. Additionally, mid-plane or edge-effect cracking will be visually observed at the time of core removal. ***SRBE monitoring will be conducted on a six month frequency.***

RAI B.2.1.31A-A3 (ACCEPTANCE CRITERIA)

Background

Section B.2.1.31A of the applicant's updated LRA submittal dated August 9, 2016, states in the Element 6 – Acceptance Criteria section, "[a] structural evaluation is needed when the CCI reaches what is classified as Tier 3 (CCI > 1mm/m)."

Issue

It is not clear to the staff to what the term "structural evaluation" is referring. Specifically, it is not clear whether this statement refers to an analysis in accordance with the deformation program (B.2.1.31B). Also, it is not clear what evaluation would be performed if the structure is not within the scope of B.2.1.31B and whether all structures within B.2.1.31B receive an analysis regardless of CCI.

Request

State whether the term "structural evaluation" in Section B.2.1.31A refers to an analysis in accordance with the deformation program (B.2.1.31B). State what evaluation would be performed if the structure is not within the scope of B.2.1.31B and whether all structures within B.2.1.31B receive an analysis regardless of CCI. If not, provide technical justification.

NextEra Energy Seabrook to Response RAI B.2.1.31A-A3 (Acceptance Criteria)

NextEra Energy Seabrook is managing the aging effects of ASR under two AMPs.

- ASR AMP—The ASR AMP is for the initial identification and classification of ASR in plant structures. The tier categorization is intended for initial screening of structures, determination of when to install extensometers, and determination of the monitoring frequency. It also states that a structural evaluation is needed when the CCI is greater than 1 mm/m (i.e., Tier 3).
- Building Deformation AMP—The Building Deformation AMP is for managing the building deformation aspects of ASR expansion. It includes a structural evaluation that considers ASR-induced loads and the deformation associated with ASR expansion. This evaluation will consist of a Susceptibility Screening Evaluation (Stage 1), an Analytical Evaluation (Stage 2), or a Detailed Evaluation (Stage 3), as appropriate. The analysis defines parameters to monitor and acceptance criteria to ensure that the structure remains bounded by the analysis. These evaluations are performed for all concrete structures within the program scope, regardless of whether the structure is classified as Tier 3 under the ASR AMP.

For ASR-affected structures within the scope of the Building Deformation AMP, the structural evaluation for building deformation fulfills the requirement in the ASR AMP for structural evaluation of Tier 3 structures. Note that these evaluations are in progress for all structures in the scope of the Building Deformation AMP that are affected by ASR. Once these evaluations are complete, there will not be an instance of a structure reaching Tier 3 without a structural evaluation already completed.

For ASR-affected structures that are within the scope of the ASR AMP but not within the scope of the Building Deformation AMP, a structural evaluation that considers the effects of ASR may not exist at the time it reaches Tier 3. In such cases, it will be necessary to perform the structural evaluation. The evaluation will be performed using the methodology defined in the Building Deformation AMP.

Once a structural evaluation is performed for building deformation, the monitoring frequency will be established based on the most stringent criteria. For example a Stage 2 Building Deformation Evaluation that is monitored on a 30 month frequency may have Tier 3 CCI locations monitored on a six month frequency and a Stage 3 Building Evaluation that is monitored on a 6 month frequency may have Tier 2 CCI locations that will also be monitored on a 6 month frequency.

NextEra Energy Seabrook has updated Aging Management Program B.2.1.31.A- Alkali-Silica Reaction to clarify the interaction of the two AMPS with regard to monitoring requirements and to indicate that the building deformation analysis under Aging Management Program B.2.1.31.B satisfies the requirement for a structural evaluation of Tier 3 locations under Aging Management Program B.2.1.31.A.

RAI B.2.1.31A-A4 (OPERATING EXPERIENCE)

Background:

SRP-LR Section A.1.2.3.10 states that an applicant should commit to a future review of plant-specific and industry operating experience to confirm the effectiveness of its aging management programs or indicate a need to develop new aging management programs.

The applicant's August 9, 2016, letter states that, with regards to large-scale testing:

- "The results of the test program demonstrated that none of the assessed limit states are reduced by ASR when ASR expansion levels in plant structures are below those evaluated in the large-scale test programs."
- "Results from the large-scale testing program are also used to support evaluations of structures subjected to deformation."
- "Data from the structural testing programs have shown that expansion in the in-plane direction plateaus at low expansion levels, while expansion in the through-thickness direction continues to increase."
- "A correlation relating expansion to reduction in elastic modulus was developed from the large scale testing program data. The correlation relating expansion to reduction in elastic modulus is applicable to reinforced concrete structures at Seabrook."

The staff noted that the methodology for computing through-wall expansion to-date is described in Report MPR-4153, which was submitted to the staff.

The "Operating Experience" program element states "Seabrook will update the Aging Management Program for any new plant-specific or industry OE"

Issue:

The applicant's above statements indicate that there is an assumption or hypothesis that the actual structures subject to ASR at Seabrook will behave as observed in the test specimens. Although the test specimens have been created to be as "representative as practical" of Seabrook two-way reinforced concrete walls, the assumption that Seabrook ASR-affected concrete will behave as seen in the test specimens has not been corroborated or validated. The staff has the following concerns:

- The methodology described in MPR 4153 should be corroborated or validated. It is not clear whether the applicant plans to corroborate or validate, over sufficient time and prior to PEO, such that the behaviors observed due to ASR in the testing specimens and assumed to correlate to Seabrook concrete are consistent.
- The effects of ASR degradation are being addressed as a first-of-a-kind issue in the US nuclear power industry without a widely-accepted or standardized approach to addressing

it, and the applicant's AMP is based primarily on the scope and data of one "plant-specific" large-scale test program. It is not clear if and how the program will corroborate or validate assumptions made, once there is data available from implementation of the program to confirm the effectiveness of the ASR Monitoring AMP, to manage aging effects for which it is credited.

Request:

Explain whether and how the ASR Monitoring program will corroborate or validate assumptions (e.g., petrographic characteristics, reduction of elastic modulus at a given expansion, 'plateau' behavior of in-plane expansion, dominant out-of-plane expansion, lack of evidence of in-plane cracking) about how structures at Seabrook would behave under ASR expansion based on observations from the testing program. If not, provide technical basis.

NextEra Energy Seabrook Response to RAI B.2.1.31A-A4 (Operating Experience)

Methodology in MPR-4153 for Determining Pre-Instrument Expansion

The first issue identified in RAI B.2.1.31A-A4 pertains to corroboration of the correlation in MPR-4153, Revision 2, "Seabrook Station – Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction," July 2016 [2] relating elastic modulus to pre-instrument expansion.

One of the fundamental challenges with developing an aging management program for ASR is determining the amount of expansion that has occurred prior to instrumenting a particular location. Crack width measurement provides a reasonable approximation in the in-plane directions, but there is not an analogous approach for the through-thickness direction. Published technical literature does not provide a methodology for determining pre-instrument expansion in the through-thickness direction. NextEra Energy Seabrook developed an empirical correlation based on the results of the MPR/FSEL large-scale test program. MPR-4153 provides the technical basis for this correlation. The following actions were taken to provide reasonable assurance of the validity and conservatism of the correlation:

- MPR obtained data from several independent tests for expansion and elastic modulus for comparison to the FSEL data. These data are compared to the FSEL data in Figure 5-4 from MPR-4153, which is reproduced below as Figure 3. The red diamonds are literature data, and the blue squares are FSEL data that were used to generate the correlation, which is represented by the purple line. As shown, the literature data follow a trend that is

[2] Provided in NextEra Energy Seabrook, LLC letter SBK-L-16153; "Supplement to License Amendment Request 16-03, Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction," September 30, 2016 (ML16279A050)

consistent with the FSEL test data and the correlation determined using the FSEL data. This validates the correlation. Also, the fact that the FSEL data and correlation compare favorably with data for a range of concretes indicates that the correlation is applicable to the concrete at Seabrook Station (which is very similar to the concrete used at FSEL).

[redacted]

Figure 3. Comparison of Literature Data to Correlation

- Literature data indicate that reduction in elastic modulus is sensitive to ASR development, and that compressive strength is a less sensitive parameter. Material property test results from the MPR/FSEL large-scale test programs are consistent with these qualitative trends.
- The methodology in MPR-4153 applies a reduction factor of [redacted]% to the normalized elastic modulus for cores removed from ASR-affected concrete at Seabrook Station. This reduced modulus is then used to determine the through-thickness expansion to date (i.e., the pre-instrument expansion). Reducing the normalized modulus is conservative as it increases the calculated expansion to date. As an example, the largest pre-instrument expansion calculated thus far for Seabrook Station is [redacted]%; this value would be [redacted]% without application of the reduction factor.

In addition to these measures, NextEra Energy Seabrook plans to corroborate the correlation using in-plant data. NextEra Energy Seabrook will obtain additional cores in the vicinity of three extensometers in the future and perform modulus testing. Using these test results, NextEra Energy Seabrook will determine the change in through-thickness expansion since installation of the extensometers and compare it to the change determined from extensometer readings. Consistency between these results will provide additional corroboration of the methodology in MPR-4153. NextEra Energy Seabrook will perform these actions at least two years prior to the PEO.

Confirmation of Overall Expansion Behavior

The second issue identified in RAI B.2.1.31A-A4 pertains to application of operating experience (OE) from the AMP at Seabrook for the purpose of corroborating the results of the test programs.

Element 10 of the AMP states that NextEra Energy Seabrook will update the AMP to address any new plant-specific OE. It includes a periodic assessment of ASR expansion behavior to confirm that the MPR/FSEL large-scale test programs remain applicable to plant structures. More specifically, at least 5 years prior to PEO and every 10 years thereafter, NextEra Energy Seabrook will perform an integrated review of expansion trends at Seabrook Station. This review will include the following specific considerations:

- Review of all cores removed to date for trends of any indications of mid-plane cracking. Such cracking was observed in the MPR/FSEL large-scale test programs, but was concluded to be an edge effect that was manifested in the test specimens but would not be expected to occur at the plant. This trending is expected to confirm that there are no mid-plane cracks in the plant.
- Comparison of in-plane expansion recorded to date to through-thickness expansion of all monitored points by plotting these data on a graph of CCI versus through-thickness expansion. This comparison is expected to show that expansion is initially similar in all directions, and eventually shows preference for the through-thickness direction, since it is not reinforced in that direction.
- Comparison of in-plane expansions and through-thickness expansions recorded to date to the limits from the MPR/FSEL large-scale test programs and check of margin for future expansion. Also, the calculated volumetric expansion will be compared to the range observed in the beam test programs and margin for future expansion will be checked.

Any deviations from the expected trends will be addressed under the Corrective Action Program. The above efforts will corroborate assumptions regarding application of the MPR/FSEL large-scale testing to structures at Seabrook Station.

Implementation

NextEra Energy Seabrook has added the steps identified in this RAI response to Element 10 of AMP B.2.1.31.A –Alkali-Silica Reaction to more specifically identify how OE from Seabrook will be used to corroborate the correlation from MPR-4153 and compare expansion behavior at Seabrook Station to the large scale test program specimens.

Also, Commitments 45 and 66 are provided as follows:

45	***Alkali-Silica Reaction (ASR) Monitoring Program***	***NextEra Energy Seabrook will obtain additional cores in the vicinity of three extensometers and perform modulus testing. Using these test results, NextEra will determine the change in through-thickness expansion since installation of the extensometers and compare it to change determined from extensometer readings. Consistency between these results will provide additional corroboration of the methodology in MPR-4153.***	***A.2.1.31.A***	***At least 2 years prior to the period of extended operation.***
66	***Alkali-Silica Reaction (ASR) Monitoring Program***	***NextEra Energy Seabrook will perform an integrated review of expansion trends at Seabrook Station by conducting a periodic assessment of ASR expansion behavior to confirm that the MPR/FSEL large-scale test programs remain applicable to plant structures. This review will include the following specific considerations:*** • ***Review of all cores removed to date for trends of any indications of mid-plane cracking.*** • ***Comparison of in-plane expansion to through-thickness expansion of all monitored points by plotting these data on a graph of CCI versus through-thickness expansion.*** • ***Comparison of in-plane expansions and through-thickness expansions recorded to date to the limits from the MPR/FSEL large-scale test programs and check of margin for future expansion. Also, the calculated volumetric expansion will be compared to the range observed in the beam test programs and margin for future expansion will be checked.***	***A.2.1.31.A***	***At least 5 years prior to the period of extended operation and every 10 years thereafter.***

RAI B.2.1.31B-B1 (SCOPE OF PROGRAM)

Background

SRP-LR section A.1.2.3.1 states that the "Scope of Program" program element should include the specific structures and components, the aging of which the program manages. The applicant's August 9, 2016, submittal states "[t]he Seabrook Building Deformation Monitoring Program provides for management of the effect of building deformation on Seismic Category 1 structures and associated components within the scope of license renewal." Also included is a list in Section B.2.1.31A of concrete structures within the scope of the license renewal structures monitoring program that will be monitored by the ASR Monitoring AMP and a list in Section B.2.1.31B of structures that will be managed by the Building Deformation program.

Issue

During its onsite audit, the staff reviewed implementing documentation and a list of structures to be evaluated under the Building Deformation program and found discrepancy between the structures listed on the implementing documentation and the August 9, 2016, submittal. Specifically, the seismic Category 1 Control Building, Diesel Generator Building, and Service Water Access (Inspection) Vault were not captured in the implementing documentation. It is not clear whether those structures are included in implementation of the Building Deformation program.

It is also unclear why the list of structures managed does not match between Section B.2.1.31A and Section B.2.1.31B; specifically, why the non-category I structures in the ASR Monitoring Program are not included in the Building Deformation Program.

Request

Confirm whether the seismic Category 1 Control Building, Diesel Generator Building, and Service Water Access (Inspection) Vault are included in the Building Deformation Program. If they are not included, explain why not. In addition, explain why the non-category I structures in the ASR Monitoring Program are not included in the Building Deformation Program.

NextEra Energy Seabrook Response to RAI B.2.1.31B-B1 (Scope of Program)

The scope of License Renewal program B.2.1.31.A, Alkali-Silica Reaction, includes all structures included in the Structures Monitoring Program B.2.1.31 including Control Building, Diesel Generator Building, and Service Water Access (Inspection) Vault. By contrast, program B.2.1.31.B, Building Deformation, does not include Non Seismic Category I structures. This is because deformation is primarily a result of expansion due to ASR in the in-plane direction of heavily reinforced concrete structures, typically Seismic Category 1 structures. In response to the staff's question, NextEra Energy Seabrook compared the structures included in the scope of program B.2.1.31.A, Alkali-Silica Reaction, to determine if any additional Non Seismic Category 1 structures should be included in program B.2.1.31.B, Building Deformation. The Non Seismic Category 1 structures currently in the scope of program B.2.1.31.A, Alkali-Silica Reaction, are primarily concrete slabs and foundations supporting steel structures in which material levels of deformation are not anticipated. NextEra Energy Seabrook did identify a single Non Seismic Category I structure, which based upon its size and characteristics could reasonably be expected to potentially exhibit deformation. This exception is the Intake and Discharge structure, which is a large vertical concrete structure. This structure is being added to the scope of program B.2.1.31.B, Building Deformation.

Aging Management Program B.2.1.31.B - Building Deformation under Program Element 1-Scope of Program (SBK-L-16013 / Enclosure 4 / Page 22) is revised as follows:

ELEMENT 1 - Scope of Program

The Seabrook Building Deformation Monitoring Program provides for management of the effect of building deformation on ~~Seismic Category 1~~ ***concrete*** structures and associated components within the scope of license renewal. Program scope includes components within the scope of license renewal contained in concrete structures within the scope of the Structures Monitoring Program. Concrete structures within the scope of this program include:

Category I Structures

- Containment Building (including equipment hatch missile shield)
- Containment Enclosure Building
- Containment Enclosure Ventilation Area
- Service Water Cooling Tower including Switchgear Rooms
- Control Building
- Control Building Make-up Air Intake Structures
- Diesel Generator Building
- Piping (RCA) Tunnels
- Main Steam and Feed Water East and West Pipe Chase
- Waste Processing Building
- Tank Farm
- Condensate Storage Tank Enclosure
- Emergency Feed Water Pump House Building, including Electrical Cable Tunnels and Penetration Areas (Control Building to Containment)
- Fuel Storage Building
- Primary Auxiliary Building including RHR Vaults
- Service Water Pump House
- Service Water Access (Inspection) Vault
- Circulating Water Pump House Building (below elevation 21'-0)
- Safety Related Electrical Manholes and Duct Banks
- Pre-Action Valve Building

Non-Category I Structures

- ***Intake & Discharge Transition Structures***

RAI B.2.1.31B-B2 (PARAMETERS MONITORED OR INSPECTED, DETECTION OF AGING EFFECTS)

Background

SRP-LR Section A.1.2.3.3 states that the "Parameters Monitored or Inspected" program element should identify the aging effects that the program manages and should provide a link between the parameter or parameters that will be monitored and how the monitoring of these parameters will ensure adequate aging management. The SRP also states that the parameters monitored or inspected should be capable of detecting the presence and extent of aging effects.

SRP-LR Section A.1.2.3.4 "Detection of Aging Effects" states that the program element describes "when," "where," and "how" program data are collected. For a condition monitoring program the discussion should provide justification that the [monitoring] method and frequency are adequate to detect aging effects before a loss of SC-intended function.

SRP-LR Section A.1.2.3.6 "Acceptance Criteria" states that the acceptance criteria, against which the need for corrective actions are evaluated, could be specific numerical values, or could consist of a discussion of the process for calculating specific numerical values of conditional acceptance criteria to ensure that the structure- and component-intended function(s) will be maintained under all CLB conditions.

The applicant's Building Deformation AMP in Section B.2.1.31B of its August 9, 2016, submittal "Parameters Monitored or Inspected" program element describes a methodology for identifying parameters to monitor for each in-scope structure. The methodology includes three "stages" of analysis or evaluation, one or more of which will be applied to each structure, that will result in threshold parameters to monitor, each with threshold limits (i.e., monitoring acceptance criteria), and a specified monitoring frequency depending on the "stage" of analysis that was applied to the structure. The applicant stated that "[a] set of monitoring elements (consisting of strain measurements, deformation measurements, seismic gap measurements, and/or other quantifiable behaviors) is established along with threshold limits for each monitoring element." The building deformation monitoring frequency for structures for each stage are provided in Table 1 of Enclosure 4 of the August 9, 2016, submittal. The "acceptance criteria" program element states that a systematic approach to evaluation [Stage 1, 2, or 3 process] of structures impacted by ASR expansion and building deformation is utilized to evaluate ASR and CLB load combinations to validate compliance with structural design code requirements.

Issue

During its onsite audit, the staff reviewed implementing documentation for the Building Deformation monitoring program and interviewed cognizant staff. The staff noted that the program does not have one set of parameters monitored or acceptance criteria, but that the applicant establishes a set of parameters to monitor and acceptance criteria for each structure. The staff also noted that the baseline structural evaluations to establish the criteria for each structure's individual building deformation monitoring were not complete for all structures in the scope of the program, and therefore the applicant could not provide the parameters monitored and monitoring method(s) for all of the structures that are in scope of license renewal (i.e., that have license renewal intended functions). The staff was also not provided comprehensive documentation of the process for performing the evaluations, including, but not limited to: (a) a detailed list of the possible monitoring parameters and monitoring method(s) for those parameters; (b) the process for determining what stage of analysis will be used for a given structure; (c) the process for determining that another analysis (different stage) is necessary; and (d) the process for selecting what parameters will be monitored and their monitoring method(s).

The section titled "Stage 2: Analytical Evaluation" states that "additional inspections are performed to measure structural strains and deformations at a broader range of critical locations of the structure." It is not clear to the staff whether (a) there is a procedure for performing the additional inspections, including location and number of additional inspections or (b) a repeatable process for determining when adequate information has been gathered.

Without either the list of parameters monitored for each structure or comprehensive understanding of the procedures and methodology for determining the parameters to be monitored and monitoring method(s) such that it is clear that the process is repeatable, the staff is not able to verify that the "parameters monitored or inspected" and "detection of aging effects" program elements are adequate in accordance with the SRP-LR.

Request

Provide, for each structure, a list of parameters monitored and their monitoring method(s), or provide a comprehensive discussion of the processes and procedures for determining the parameters to monitor and monitoring method(s) for structures within the scope of the Building Deformation Program in a manner that would demonstrate repeatability of the process. As a minimum, the discussion of the process should address the items listed in the "Issue" section above.

NextEra Energy Seabrook Response RAI B.2.1.31B-B2 (Parameters Monitored Or Inspected, Detection Of Aging Effects)

The ASR deformation program was developed to qualify Seabrook structures for deformation attributed to the cumulative effects of concrete ASR expansion. All Category I concrete structures at Seabrook Station that are affected by ASR will be analyzed for deformation. The detailed steps for gathering deformation measurements and analyzing each structure for ASR effects are building-specific, but the defined process is outlined below. The amount of field data used and the level of detail required in the analysis vary depending on the stage of analysis for each building.

<u>Review, Acquisition, and Assessment of Deformation Data</u> - The initial step in the deformation analysis process involves reviewing existing data and performing additional field surveys of structures. Since ASR was initially identified at Seabrook in 2009, NextEra Energy Seabrook has gathered visual inspection data and obtained ASR expansion measurement data for each structure through the Structures Monitoring Program. Data also were collected in walkdowns to identify potential interactions between deformed structures and plant components. Recently, seismic gap measurements were obtained for building deformation. Collectively, the ASR expansion and building deformation measurement data can be used to analytically determine the deformed shape of each structure.

NextEra Energy Seabrook will initially review the data obtained for each structure to determine if additional measurements are needed to characterize the deformed shape of the structure. A review of the structure and associated data determines which of the three stages is appropriate to analyze each structure. The stage of analysis and the amount of field data required for each building depends on the following considerations:

- The design margins of the undeformed structure when design basis loads are applied;
- The locations where design margins are a minimum;
- The magnitude of ASR expansion and deformation measured in the structure;
- The orientation and complexity of deformation measurements, and;
- The complexity of the structure.

The review of data assesses whether there are sufficient data to characterize structure deformation corresponding to the stage of analysis used to evaluate the structure. If the data assessment concludes that more data are necessary to characterize ASR expansion in the structure, then additional data will be obtained in the form of Crack Index (CI) measurements in ASR affected areas, identification/measurements of expansion induced cracks, measurements between points on the structure, and/or measurements relative to adjacent structures (e.g., seismic gap measurements).

The amount of data needed for the analysis increases with the stage of analyses being performed to qualify each structure. The Stage 1 analysis is based on maximum ASR strain measured by Crack Index (CI) measurements performed at locations with most pattern cracking based on visual inspection for a structure or a region of the structure. The amount of CI data that are needed increases when a structure is evaluated for a higher stage of analysis. A Stage 3 analysis includes a sufficient number of CI measurements to accurately calculate the mean ASR strain in a region of a structure. The number of CI measurements for a region will be determined through one of the following approaches:

- For large regions, a number of CI measurements are selected such that additional CI measurements would not cause a significant change to the computed mean ASR strain.
- For small regions, the number of CI measurement grids will be based on the ratio of measured area to the total area.

Alternatively, the mean ASR strain can be computed using a smaller number of CI measurements if close-up visual inspection of the region affirms that the collected measurements are representative of the region. A Stage 2 analysis uses a quantity of data that is between those described for Stages 1 and 3. Other data such as seismic gap measurements, displacement, deformations, width of structural cracks (if any), and overall expansion for structure are used with graded approach based on the stage of analysis.

Quantify ASR Demands – A finite element model (FEM) will be developed for Stage 2 or 3 analyses in ANSYS that represents the undeformed shape of each structure. The dimensions of the model will be based on design drawings. The model will include all relevant portions of the structure and its foundation.

ASR expansion is simulated in the FEM by expanding (i.e., straining) the modeled concrete material at locations where evidence of ASR is observed in the actual structure. The magnitude and distribution of the ASR expansion applied to the FEM is selected to match field measurements and observations. Creep, shrinkage, and swelling that have occurred since each structure was erected could also affect building long term deformation. Although the deformation caused by these long-term conditions is small, these mechanisms are considered in each analysis to more accurately quantify the deformation caused by ASR and long-term loadings. Once the creep, shrinkage, swelling, and ASR expansion are applied to the FEM along with the static deadweight of the structure as a body force, a deformed shape is produced. The deformed shape determined from FEM is compared to the various measurements of the actual deformed shape obtained in the Review, Acquisition and Assessment phase.

Because of inhomogeneity of concrete in structures and the level of detail used to model ASR-affected regions, it may be necessary to adjust the concrete expansion imposed in the ASR-affected regions of the model or make refinements to the shape of ASR regions, while remaining consistent with field measurements, to correlate the predicted shape and extent of deformation with the actual measurements from the structure. If the actual deformed shape of a structure differs from the shape simulated by the FEM, then there may be additional loads on the structure that account for the differences. If the deformed structure cannot be accurately predicted using the FEM and the available measurements, additional measurements will be obtained and the process of verifying the deformation analysis model will be repeated.

Analysis of ASR-Impacted Structure – The overall objective of the deformation analysis is to assess each structure's capacity to withstand design basis loads in conjunction with the ASR expansion loads. Once the FEM is verified by comparing the simulated deformations and strains to measurements of the actual structure, the magnitude of ASR expansion in the affected areas of the structure is amplified by a factor to account for potential future ASR expansion. Then the original design load demands are added to ASR load demands based on the load combinations specified in Seabrook UFSAR Tables 3.8-1, 3.8-14, and 3.8-16. In Stage 3 evaluations, the original design demands are recomputed by applying the associated loads to the FEM. In other stages, the original design demands are generally taken from original design calculations. The results from these analyses are compared to ACI 318-71 or ASME Section III acceptance criteria, as appropriate.

Establish Parameters Monitored and Threshold Limits – The specific locations where ASR exists in each structure and the critical areas where the margin to Licensing Basis structural design code and design basis acceptance criteria are most limiting influence the locations and types of measurements that are used to monitor each structure. The results from the deformed structure analysis will be reviewed to identify the critical areas for meeting the structural acceptance and seismic gap criteria and the ASR regions that influence the calculated results in the critical areas. Monitoring parameters will be identified and their locations specified based on the review.

Field inspections shall be performed to obtain observations and measurements that can be used to quantify ASR loads applied to each structure. A list of observations and measurements that may be recorded during field inspection is provided in Table 1. A document review shall be performed for each structure. Documents that are necessary to review include design drawings and design criteria. Other additional documents shall also be reviewed as needed in order to perform susceptibility evaluations. All documents reviewed shall be the latest available revision. A list of documents that may be reviewed is provided in Table 2.

The number of monitoring locations and the types of measurements taken will be influenced by the sensitivity of the results to the level of expansion or deformation in these regions as well as the size and shape of ASR-affected areas in the structure.

As previously stated, the building deformation analysis process includes three stages – a Stage 1 Screening Evaluation, a Stage 2 Analytical Evaluation, and a Stage 3 Detailed Evaluation. However, analysis of a structure by proceeding through all three stages in sequence is not necessary. The process is designed to address increasing levels of structure deformation which may require more accuracy and precision in the analysis method to demonstrate that structural acceptance criteria are satisfied. The evaluation for a structure may begin at a more advanced stage (e.g., Stage 2) when structural margins may be challenged. The decision to proceed directly to Stage 2 or Stage 3 is based on a review of the available design margin, the magnitude of ASR expansion measured in the structure, and the complexity of the structure.

Table 1. Field Observations and Measurements for Building Deformation Evaluations

	Parameter	Description
	Cracking suspect of ASR(visual observations)	Qualitative visual observations made of cracking that exhibits visual indications of ASR and ASR-related features, using industry guidelines
	Cracking not suspect of ASR (visual observations	Qualitative visual observations made of cracking that do not exhibit indications of ASR. These cracks may be structural (i.e. caused by stresses acting on the structure) or caused by shrinkage or other mechanisms aside from ASR.
	Other structural or material distress (visual observations)	Qualitative visual observations made of structural distress, such as buckled plates, broken welds, spalled concrete, delaminated concrete, displacement at embedded plates, damage to coatings, and chemical staining.
	Crack index	Quantitative measurement of in-plane cracking on a concrete structural component using the cracking index measurement procedure
	In-plane strain rate	Quantitative measurement of length between two points installed on a concrete component using a removable strain gage. In-plane expansion is computed as the change in length between measurements recorded at different times.
	Through-thickness expansion	Quantitative measurement of the thickness of a concrete component using an extensometer device. Through-thickness expansion is computed as the change in thickness between measurements recorded at different times.
	Through-thickness strain rate	Calculated value based on measurements of through-thickness expansion over a period of time.
	Individual crack widths/lengths	Quantitative measurement of individual crack widths using either a crack card, an optical comparator, or any other instrument of sufficient resolution. Such measurements shall be accompanied by notes, sketches, or photographs that indicate the pattern of the cracks and their length. Also included in this category are tools that quantify the change in crack widths, such as mountable crack gages, extensometers, and invar wires
	Seismic isolation joints	Quantitative measurement of the width of seismic joints that separate two adjacent structures. Also included in this category are qualitative observations of distress in seals covering or filling isolation joints, such as tears, wrinkles, and bubbles.
	Structure dimensions	Quantitative measurement of a structure's dimensions or the distance between two adjacent structures. Included in this category are measurements of plumbness of walls, levelness of slabs, and bowing/bending of members.
	Equipment/conduit offsets	Quantitative measurement or visual observation of building deformation through the misalignment of equipment and/or the deformation of flexible conduit joints.

Table 2. Document Review for Building Deformation Evaluations

		Documents	Description
Review Necessary		Structural design drawings and specifications	Structural design drawings, including excavation drawings, backfill drawings, and adjacent structure drawings as needed
		Original structural design criteria	Structural design criteria, including the Updated Final Safety Analysis Report (UFSAR), documenting loads, load combinations, and strength acceptance criteria for which the structure was originally designed
		Structural design calculations	Structural design calculations documenting the underlying assumptions of the original structural design and original design demands and capacities.
Review As Needed		Construction documentation	Construction documents, drawings, and photos documenting construction stages, concrete placement, etc. This category also includes as-built drawings and survey data following construction.
		Documentation of structural and material tests	Existing documentation of testing, including petrography, that has been performed on the structure or the materials of the structure.
		Engineering changes made to the structure after construction	Changes to the structure that do not appear on the design drawings.
		Documented observations/ measurements of structural behavior/distress	Existing documentation of structural distress or other structural behavior that may indicate the presence of ASR.
		Documented repairs made to the structure	Existing documentation of repairs made to the structure that may indicate the presence of ASR.
		Other documents	E.g., Action Requests, Condition Reports, SMP Database

NextEra Energy Seabrook has updated Aging Management Program B.2.1.31.B- Building Deformation Element 3 to define the input parameters to building deformation analysis. To provide for repeatability and consistency for analysis performed for Building Deformation, Next Era will develop a design standard to implement Aging Management Program B.2.1.31B Building Deformation, Program Element 3 - Parameters Monitored/Inspected. The design standard will clarify the deformation evaluation process and provide an auditable format to assess it. The design standard will include steps for each of the three evaluation stages that include parameters monitored, basis for why the parameter is monitored, and conditions that prompts action for the subsequent step. The design standard will also include a checklist that is used to facilitate and document the steps taken during the deformation evaluation process for each of the structures. Commitment 91 is revised as follows:

91	Building Deformation Monitoring	Implement the Building Deformation Monitoring Program Enhance the Structures Monitoring Program to require structural evaluations be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained. Evaluations of structures will validate structural performance against the design basis, and may use results from the large-scale test programs, as appropriate. Evaluations for structural deformation will also consider the impact to functionality of affected systems and components (e.g., conduit expansion joints). NextEra Energy Seabrook will evaluate the specific circumstances against the design basis of the affected system or component. Enhance the Building Deformation AMP to include additional parameters to be monitored based on the results of the CEB Root Cause, Structural Evaluation and walk downs. Additional parameters monitored will include: alignment of ducting, conduit, and piping; seal integrity; laser target measurements; key seismic gap measurements; and additional instrumentation. ***Develop a design standard to implement Aging Management Program B.2.1.31B Building Deformation, Program Element 3 - Parameters Monitored/Inspected. The design standard will clarify the deformation evaluation process and provide an auditable format to assess it. The design standard will include steps for each of the three evaluation stages that include parameters monitored, basis for why the parameter is monitored, and conditions that prompts action for the subsequent step.***	A.2.1.31B	March 15, 2020

RAI 3.5-A1 (AGING MANAGEMENT REVIEW)

Background

10 CFR 54.21(a)(3) states that for each structure and component (SC) subject to an aging management review (AMR) as identified in an applicant's integrated plant assessment, the applicant must demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation.

The applicant's letter dated August 9, 2016, states in the "Scope of Program" program element that the Building Deformation aging management program "provides for management of the effect of building deformation on Seismic Category 1 structures and associated components within the scope of license renewal. Program scope includes components within the scope of license renewal contained in concrete structures within the scope of the Structures Monitoring Program."

Issue

The applicant's August 9, 2016, submittal does not include Table 2 AMR line items for SCs that may be subject to aging effects of building deformation, including supported SCs. Since building deformation (i.e., global manifestations of ASR expansion) is being managed by the Building Deformation program, it is not clear whether the applicant evaluated the need to revise the AMR tables associated with the affected SCs and identify whether building deformation would result in aging effects not previously considered in the LRA. In addition, it is not clear if the other program(s) that manage any affected components employ the methods and frequency of inspection to bound those of the Building Deformation program to ensure adequate aging management for affected components.

Request

Provide the results of any evaluation in accordance with the requirements of 10 CFR 54.21(a) that demonstrates that for all SCs affected by building deformation caused by ASR expansion, that either (a) the Building Deformation program will specifically inspect and manage for the effects of building deformation; (b) building deformation will not result in behavior of supported SCs that was not previously considered; or (c) the other AMPs that manage aging of the SCs are adequate to ensure that the effects of building deformation do not affect the SCs from performing their intended functions.

NextEra Energy Seabrook Response RAI 3.5-A1 (Aging Management Review)

Baseline inspection of buildings susceptible to Building Deformation has identified various categories of equipment affected by deformation as listed in Element 3-*Parameters Monitored/Inspected* of program B.2.1.31.B- *Building Deformation.* The impact of building deformation does not alter the intended function or alter a behavior of supported structure and components that was not previously considered As discussed in Building Deformation Program Element 4- *Detection of Aging Effects* (SBK-L-16013 / Enclosure 4 / Page 32) the effect of Building Deformation on components will be monitored by Program B.2.1.31 Structures Monitoring [emphasis added]

ELEMENT 4 - Detection of Aging Effects

As discussed in Element 3 baseline walkdowns to identify the potential effects caused by building deformation will be performed. The results of the baseline walkdowns will be used to determine the key assumptions in the structural analysis in addition to determining the monitoring frequencies for equipment impacted by building deformation. Subsequent monitoring will be performed as part of future Structures Monitoring Program (SMP) walkdowns. The inspection frequencies identified by Table 1 will be applied in locations where symptoms of deformation are identified; otherwise, the inspection frequency will follow the requirements of the SMP. The SMP includes periodic visual inspection of structures and components for the detection of aging effects specific for that structure. The inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found.

Aging Management Program B.2.1.31- Structures Monitoring is revised to include the following statement. (LRA page B-222):

The station SMP identifies plant equipment impacted or potentially impacted by building deformation through baseline and periodic walkdowns of the structures. The as-found conditions of the items of interest are evaluated and recommendations for repair or periodic monitoring are established in accordance with the Corrective Action Program.

Enclosure 2 to SBK-L- 16181

Seabrook Station Updated Final Safety Analysis Report

Section A.2.1.31 for Structures Monitoring,

Section A.2.1.31A for Alkali-Silica Reaction (ASR) and

Section A.2.1.31B for Building Deformation

A.2.1.31 Structures Monitoring Program

The Structures Monitoring Program includes the Masonry Wall Program and the Inspection of Water Control Structures Associated with Nuclear Power Plants Program.

The Structures Monitoring Program is implemented through the plant Maintenance Rule Program, which is based on the guidance provided in NRC Regulatory Guide 1.160 "*Monitoring the Effectiveness of Maintenance at Nuclear power Plants*" and NUMARC 93-01 "*Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*", and with guidance from ACI 349.3R, "*Evaluation of Existing Nuclear Safety-Related Concrete Structures*". The Structures Monitoring Program was developed using the guidance of these three documents. The Program is implemented to monitor the condition of structures and structural components within the scope of the Maintenance Rule, such that there is no loss of structure or structural component intended function.

A.2.1.31A ALKALI-SILICA REACTION (ASR) MONITORING

The plant specific ASR Monitoring Program manages cracking due to expansion and reaction with aggregates of concrete structures within the scope of License Renewal. The potential impact of ASR on the structural strength and anchorage capacity of concrete is a consequence of strains resulting from the expansive gel.

The ~~Structural~~ ***Structures*** Monitoring Program ***and Section XI Subsection IWL Program*** perform visual inspections of the concrete structures at Seabrook for indications of the presence of alkali-silica reaction (ASR). ASR involves the formation of an alkali-silica gel which expands when it absorbs water. This expansion is volumetric in nature but is most readily detected by visual observation of cracking on the surface of the concrete. This cracking is the result of expansion that is occurring in the in-plane directions. Expansion is also occurring perpendicular (through the thickness of the wall) to the surface of the wall, but cracking will not be visible in this direction from the accessible surface. Cracking on the surface of the concrete is typically accompanied by the presence of moisture and efflorescence. Concrete affected by expansive ASR is typically characterized by a network or "pattern" of cracks. Micro-cracking due to ASR is generated through forces applied by the expanding aggregate particles and/or swelling of the alkali-silica gel within and around the boundaries of reacting aggregate particles. The ASR gel may exude from the crack forming white secondary deposits at the concrete surface. The gel also often causes a dark discoloration of the cement paste surrounding the crack at the concrete surface. If "pattern" or "map" cracking typical of concrete affected by ASR is identified, an evaluation will be performed to determine further actions.

ASR is primarily detected by non-intrusive visual observation of cracking on the surface of the concrete. The cracking is typically accompanied by the presence of moisture and efflorescence. ASR may also be detected or confirmed by removal of concrete cores and subsequent petrographic analysis.

Monitoring of crack growth is used to assess the in-plane expansion associated with ASR and to specify monitoring intervals. A Combined Cracking Index (CCI) is established at thresholds at which structural evaluation is necessary (see table below). The Cracking Index (CI) is the summation of the crack widths on the horizontal or vertical sides of 20-inch by 30-inch grid on the ASR-affected concrete surface. The horizontal and vertical Cracking Indices are averaged to obtain a Combined Cracking Index (CCI) for each area of interest. A CCI of less than the 1.0 mm/m can be deemed acceptable with deficiencies (Tier 2). Deficiencies determined to be acceptable with further review are trended for evidence of further degradation. The change from qualitative monitoring to quantitative monitoring occurs when the Cracking Index (CI) of the pattern cracking equals or is greater than 0.5 mm/m in the vertical and horizontal directions. Concrete crack widths less than 0.05 mm cannot be accurately measured and reliably repeated with standard, visual inspection equipment. A CCI of 1.0 mm/m or greater requires structural evaluation (Tier 3). All locations meeting Tier 3 criteria will be monitored via CCI ***in-plane expansion) and borehole extensometers (through-thickness expansion)*** on a ½ year (6-month) inspection frequency ~~and added to the through-thickness expansion monitoring via extensomete~~rs. All locations meeting the Tier 2 structures monitoring criteria will be monitored on a 2.5 year (30-month) frequency. CCI correlates well with strain in the in-plane directions and the ability to visually detect cracking in exposed surfaces making it an effective initial detection parameter. In the event ASR monitoring results indicate a need to amend either the monitoring program acceptance criteria or the frequency of monitoring, NextEra Energy Seabrook will take such action under the Operating Experience element of the Alkali-Silica Reaction Monitoring Program.

Tier	Structures Monitoring Program Category	Recommendation for Individual Concrete Components	Criteria
3	Unacceptable (requires further evaluation)	• Structural Evaluation • Implement enhanced ASR monitoring, such as through-wall expansion monitoring using Extensometers.	1.0 mm/m or greater Combined Cracking Index (CCI)
2	Acceptable with Deficiencies	Quantitative Monitoring and Trending	• 0.5 mm/m or greater CCI • CI of greater than 0.5 mm/m in the vertical and horizontal directions.
		Qualitative Monitoring	Any area with visual presence of ASR (as defined in FHWA-HIF-12-022) accompanied by a CI of less than 0.5 mm/m in the vertical and horizontal directions.
1	Acceptable	Routine inspection as prescribed by the Structural Monitoring Program	Area has no indications of pattern cracking or water ingress- No visual symptoms of ASR

The Alkali-Silica Reaction Monitoring Program was initially based on published studies describing screening methods to determine when structural evaluations of ASR affected concrete are appropriate. Large scale destructive testing of concrete beams with accelerated ASR has confirmed that parameters being monitored are appropriate to manage the effects of ASR and that an acceptance criterion of 1 mm/m provides sufficient margin ***with regard to the effect of ASR expansion on structural capacity.***

For heavily reinforced structures, ~~CCI is limited in~~ in-plane expansion ***is limited.*** ~~and therefore~~ CCI has been observed in the large scale test programs to plateau at a relatively low level of accumulated strain (approximately 1 mm/m). ~~No structural impacts from ASR have been seen at these plateau levels in the large scale testing program at the University of Texas at Austin, Ferguson Structural Engineering Laboratory.~~ While CCI remains useful for the detection and monitoring of ASR at the initial stages, an additional monitoring parameter in the out-of-plane direction is required to monitor more advanced ASR progression. ASR expansion in the out-of-plane direction will be monitored by borehole extensometers installed in drilled core bore holes. In the selected locations, cores will be removed for modulus testing to establish the level of through-thickness expansion to date. Instruments (extensometers) will be placed in the resulting bore holes to monitor expansion in this direction going forward so the limits specified below are maintained.

Structural Design Issue	Criteria[3]
Flexure & reinforcement anchorage	See FP#101020 - Section 2.1 ***for limit on through-thickness expansion***
Shear	See FP#101020 - Section 2.1 ***for limit on through-thickness expansion***
Anchor bolts and structural attachments	See FP#101020 - Section 2.1 ***for limit on in-plane expansion***

A.2.1.31B BUILDING DEFORMATION MONITORING

The Building Deformation Monitoring Program is a plant specific program implemented under the existing Maintenance Rule Structures Monitoring Program. Building Deformation is an aging mechanism that may occur as a result of other aging effects of concrete. Building Deformation at Seabrook is primarily a result of the alkali silica reaction (ASR) but can also result from swelling, creep, and shrinkage. Building deformation can cause components within the structures to move such that their intended functions may be impacted.

[3] Expansion Limit Criteria is considered proprietary to NextEra Seabrook. FP #101020 MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," July 2016, was previously submitted to the NRC in SBL-L-16071; License Amendment Request 16-03; Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I; Structures with Concrete Affected by Alkali-Silica Reaction; Dated August 1, 2016

The Building Deformation Monitoring Program uses visual inspections associated with the Structures Monitoring Program and cracking measurements associated with the Alkali-Silica Reaction program to identify buildings that are experiencing deformation. The first inspection is a baseline to identify areas that are exhibiting surface cracking. The surface cracking will be characterized and analytically documented. This inspection will also identify any local areas that are exhibiting deformation. The extent of surface cracking will be input into an analytical model. This model will determine the extent of building deformation and the frequency of required visual inspections.

For building deformation, location-specific measurements (e.g. via laser target and gap measurements) will be compared against location-specific criteria to evaluate acceptability of the condition.

Structural evaluations will be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained. Evaluations of structures will validate structural performance against the design basis, and may use results from the large-scale test programs, as appropriate.

Evaluations for structural deformation will also consider the impact to functionality of affected systems and components (e.g. conduit expansion joints). NextEra Energy Seabrook will evaluate the specific circumstances against the design basis of the affected system or component. Structural evaluations will be used to determine whether additional corrective actions (e.g., repairs, additional inspections and/or analysis) to the concrete or components are required. Specific criteria for selecting effective corrective actions will be evaluated on a location-specific basis.

Enclosure 3 to SBK-L- 16181

Seabrook Station License Renewal Application

Section B.2.1.31 for Structures Monitoring,

Section B.2.1.31A for Alkali-Silica Reaction (ASR) and

Section B.2.1.31B for Building Deformation

B.2.1.31 Structures Monitoring Program

Program Description

The Seabrook Station Structures Monitoring Program (SMP) is an existing program that will be enhanced to ensure provision of aging management for structures and structural components including bolting within the scope of this program. The Structures Monitoring Program is implemented through the Seabrook Station Maintenance Rule Program, which is based on the guidance provided in NRC Regulatory Guide 1.160, Revision 2, *"Monitoring the Effectiveness of Maintenance at Nuclear Power Plants"* and NUMARC 93-01, Revision 2, *"Industry Guidance for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*", and with guidance from ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures". The Seabrook Station Structures Monitoring Program was developed using the guidance of these three documents to monitor the condition of structures and structural components within the scope of the Maintenance Rule, such that there is no loss of structure or structural component intended function.

The Seabrook Station Structures Monitoring Program includes periodic visual inspection of structures and structural components for the detection of aging effects specific for that structure. These inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found. A structure found in a harsh environment is defined as one that is in an area that is subject to outside ambient conditions, very high temperature, high moisture or humidity, frequent large cycling of temperatures, frequent exposure to caustic materials, or extremely high radiation levels. For structures in these harsh environments, the inspection is conducted on a five year basis (plus or minus one year due to outage schedule and two inspections within ten years). Structures not found in areas qualifying as a harsh environment are classified as being in a mild environment, and are inspected on a ten year basis (plus or minus one year due to outage schedule and two inspections within twenty years).

Individuals conducting the inspection and reviewing the results are qualified per the Seabrook Station Structures Monitoring Program, which is in accordance with the requirements specified in ACI 349.3R-96, *"Evaluation of Existing Nuclear Safety related Concrete Structures"*. Individuals conducting the inspection and reviewing the results are to possess expertise in the design and inspection of steel, concrete and masonry structures. These individuals must either be a licensed Professional Engineer experienced in this area, or will work under the direction of a licensed Professional Engineer experienced in this area.

The station SMP identifies plant equipment impacted or potentially impacted by building deformation through baseline and periodic walkdowns of the structures. The as-found conditions of the items of interest are evaluated and recommendations for repair or periodic monitoring are established in accordance with the Corrective Action Program.

Detection of aggressive subsurface environments will be completed through the sampling of groundwater. This procedure monitors groundwater for chloride concentration, sulfate concentration and pH on a 5 year basis

The Structures Monitoring Program will include an external surface inspection of the aboveground steel tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-AB-TK-29. This inspection will inspect the paint or coating for cracking, flaking, or peeling.

Examination of inaccessible areas, such as buried concrete foundations, will be completed during inspections of opportunity or during focused inspections. An evaluation of these opportunistic or focused inspections for buried concrete will be performed under the Maintenance Rule Program every 5 years (if no opportunistic inspection was performed during a 5-year period, a focused 5 year inspection is required) to ensure that the condition of buried concrete foundations on site is characterized sufficiently to provide reasonable assurance that the foundations on site will perform their intended function through the period of extended operation. Additional inspections may be performed in the event that an opportunistic or focused inspection or visible portions of the concrete foundation reveal degradation and will be entered into the Corrective Action Program (CAP).

Concrete structures were constructed equivalent to recommendations in ACI 201.2R, *"Guide for Making a Condition Survey of Concrete in Service"*. Loss of material due to leaching of calcium hydroxide is considered to be an aging effect requiring management for Seabrook Station. There have been indications of leaching in below grade concrete in Seabrook Station structures. Leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Resistance to leaching is enhanced by using a dense, well-cured concrete with low permeability. These structures are designed in accordance with ACI 318 and constructed in accordance with ACI 301 and ASTM standards. Nevertheless, Seabrook Station manages loss of material due to leaching of calcium hydroxide with visual inspection through the Structures Monitoring Program.

Seabrook Station has scheduled specific actions to determine the effects of aggressive chemical attack due to high chloride levels in the groundwater. Seabrook Station has scheduled concrete testing during the second and third quarter of 2010. An evaluation will be performed based on the results of the testing and a determination of the concrete condition which may lead to additional testing or increased inspection frequency. Testing of concrete may consist of the following:

a. concrete core samples
b. penetration resistance tests
c. petrographic analysis of the concrete core samples
d. visual inspection of rebar as they are exposed during the concrete coring

Seabrook will evaluate the results of the testing and, if required, undertake additional corrective actions in accordance with the Structures Monitoring Program CAP.

The Seabrook Station Structures Monitoring Program does not credit protective coatings for management of aging effects on structures and structural components within the scope of this program.

There are no preventative actions specified in the Seabrook Station Structures Monitoring Program, which includes implementation of NUREG-1801 XI.S5, XI.S6, and XI.S7. These are monitoring programs only.

The parameters monitored in the Seabrook Station Structures Monitoring Program are in agreement with ACI 349.3R-96 and ASCE 11-90, "*Structural Condition Assessment of Buildings*".

Concrete deficiencies are classified using the criteria specified in the Seabrook Station Structures Monitoring Program, which is based on the guidance provided in ACI 201.1R-2, "*Guide for Making a Condition Survey of Concrete in Service*".

As noted in the Seabrook Station response to NRC IN 98-26, *"Settlement Monitoring and Inspection of Plant Structures Affected by Degradation of Porous Concrete Subfoundations"*, porous concrete was not used in the construction of building sub-foundations at Seabrook.

Monitoring of structures and structural components in the scope of the Seabrook Station Structures Monitoring Program is performed in compliance with Regulatory Position 1.5 of NRC Regulatory Guide 1.160 The condition of all structures within the scope of this program is assessed on a periodic basis as specified by 10 CFR 50.65. Structures that do not meet their design basis at the time of inspection due to the extent of degradation, or that may not meet their design basis at the next normally scheduled inspection due to further degradation without intervention are entered into the Corrective Action Program and evaluated for corrective action and/or additional inspections as delineated in 10 CFR 50.65(a)(1). In addition, structures may also be scheduled for follow-up inspections following the completion of any corrective actions to that structure.

The condition of any structure subject to additional inspections or corrective actions is recorded through Seabrook Station Structures Monitoring Program reports to provide a basis for scheduling additional inspections and any required corrective actions in the future, as specified the Seabrook Station Structures Monitoring Program.

Structures that are determined to be acceptable under the Maintenance Rule structural inspections are monitored as specified in 10 CFR 50.65(a)(2).

Evaluations of a structure's condition assess the extent of any degradation of the structural member in accordance with industry standards and the judgment of the qualified individuals performing the inspections.

The acceptance guidelines in the Seabrook Station Structures Monitoring Program are a three-tier hierarchy similar to that described in ACI 349.3R-96, which provides quantitative degradation limits. Under this system, structures are evaluated as being acceptable, acceptable with deficiencies, or unacceptable. Evaluations of a structure's condition are completed according to the guidelines set forth in the Seabrook Station Structures Monitoring Program.

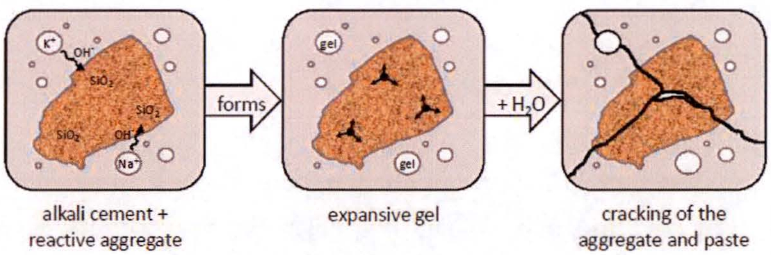
B.2.1.31A ALKALI-SILICA REACTION

PROGRAM DESCRIPTION

The Alkali-Silica Reaction Aging Management Program is a new plant specific program being implemented under the existing Maintenance Rule Structures Monitoring Program that will manage the aging effects related to Alkali-Silica Reaction of each structure and component subject to an Aging Management Review, so that the intended function(s) will be maintained consistent with the current licensing basis for the period of extended operation.

Alkali-Silica Reaction

Alkali-Silica Reaction (ASR) is an aging mechanism that may occur in concrete under certain circumstances. It is a reaction between the alkaline cement and reactive forms of silicate material (if present) in the aggregate. The reaction, which requires moisture to proceed, produces an expansive gel material. This expansion results in strains in the material that can produce micro-cracking in the aggregate and in the cement paste. The potential impact of ASR on the structural strength and anchorage capacity of concrete is a consequence of strains resulting from the expansive gel. These strains produce the associated cracking. Because the ASR mechanism requires the presence of moisture in the concrete, ASR has been predominantly detected in groundwater impacted portions of below grade structures, with limited impact to exterior surfaces of above grade structures.



ASR Expansion Mechanism

Impact of Confinement

Reinforcing steel, loads on the concrete structure (i.e., deadweight of the structure itself), and the configuration of the structure provide confinement that restrains in-situ expansion of the gel and limits the resulting cracking in concrete.

Since the impact of ASR on mechanical properties relates to the extent of cracking, restraint of the expansion limits the reduction of in-situ mechanical properties and overall degradation of structural performance. There is a prestressing effect that occurs when reinforcement restrains the expansion caused by ASR. This effect is similar to concrete prestressing or analogous to pre-loading a bolted joint.

The concrete prestressing effect is only present when the concrete is confined. If the concrete is removed from the stress field, the concrete prestressing effect is lost. For example, a core taken from a reinforced concrete structure that has been affected by ASR will lose the confinement provided by the reinforcement and concrete surrounding the sample, and therefore is no longer representative of the concrete within its structural context.

Seabrook Station Concrete

The concrete mix designs used in original construction at Seabrook utilized an aggregate that was susceptible to ASR, which was not known at the time. Although the testing was conducted in accordance with the ASTM C289 standards, the standard was subsequently identified as limited in its ability to predict long term ASR for moderate to low reactive aggregates. ASTM C289 has since been withdrawn.

In 2009, Seabrook tested seasonal groundwater samples to support the development of a License Renewal Application. The results showed that the groundwater had become aggressive and Seabrook initiated a comprehensive review of possible effects to in-scope structures.

A qualitative walkdown of plant structures was performed and the "B" Electrical Tunnel was identified as showing the most severe indications of groundwater infiltration. Concrete core samples from this area were removed, tested for compressive strength and modulus of elasticity, and subjected to petrographic examinations. While the results showed that both compressive strength and modulus of elasticity had declined, the structures were determined to be within design basis and remain operable. The results of the petrographic examinations also showed that the samples had experienced Alkali-Silica Reaction (ASR). This discovery initiated an Extent of Condition evaluation. Because the ASR mechanism requires the presence of moisture or very high humidity in the concrete, ASR has been predominantly detected in portions of below-grade structures, with limited impact to exterior surfaces of above grade structures.

Large-Scale Testing Program

The structural assessment of ASR-affected structures at Seabrook Station considered the various limit states for reinforced concrete and applied available literature data to evaluate structural capacity. This evaluation identified gaps in the publicly available test data and the applicability to the reinforcement concrete at Seabrook. The limited available data for shear capacity and reinforcement anchorage for ASR-affected reinforced concrete with two-dimensional reinforcement mats were not representative of Seabrook Station. This conclusion was driven largely by the facts that the literature data for reinforcement anchorage were from a test method that ACI indicates is unrealistic and the literature data for shear capacity were from test specimens only inches in size. Additionally, no data were available on anchor bolt capacity on reinforced concrete with two dimensional reinforcement mats like Seabrook Station.

The need for Seabrook-specific testing was driven by limitations in the publicly available test data related to ASR effects on structures. Most research on ASR has focused on the science and kinetics of ASR, rather than engineering research on structural implications. Although structural testing of ASR-affected test specimens has been performed, the application of the conclusions to a specific structure can be challenged by lack of representativeness in the data (e.g., small-scale specimens; poor test methods; different reinforcement configuration). The large-scale test programs undertaken by NextEra Energy Seabrook provided data on the limit states that were essential for evaluating seismic Category I structures at Seabrook Station. The data produced from these programs were a significant improvement from the data in published literature sources, because test data across the range of ASR levels were obtained using a common methodology and identical test specimens. The results were used to assess the structural limit states and to inform the assessment of design considerations.

The large-scale test programs included testing of specimens that reflected the characteristics of ASR-affected structures at Seabrook Station. Tests were completed at various levels of ASR cracking to assess the impact on selected limit states. The extent of ASR cracking in the test specimens was quantified by measuring the expansion in the in-plane and through-thickness specimen dimensions. The in-plane dimension refers to measurements taken in a plane parallel to the underlying reinforcement bars. There was no reinforcement in the test specimen through-thickness direction (perpendicular to the in-plane direction). ASR expansion measurements were monitored throughout testing. The test programs assessed all relevant limit states except compression (i.e., flexure and reinforcement anchorage, shear, and anchor bolts and structural attachments to concrete). The results of the test program demonstrated that none of the assessed limit states are reduced by ASR when ASR expansion levels in plant structures are below those evaluated in the large-scale test programs.

The effect of ASR on compressive strength was not assessed in the large-scale test program. An evaluation of compression using existing data from published literature sources was performed. The evaluation concluded that ASR expansion in reinforced concrete results in compressive load that should be combined with other loads in design calculations. However, ASR does not reduce the structural capacity of compression elements.

The specimens used in the large-scale test programs experienced levels of ASR that bound ASR levels currently found in Seabrook structures (i.e., are more severe than at Seabrook), but the number of available test specimens and nature of the testing prohibited testing out to ASR levels where there was a clear change in limit state capacity. Because there is not testing data for these more advanced levels of ASR, periodic monitoring of ASR at Seabrook is necessary to ensure that the conclusions of the large-scale test program remain valid – that the level of ASR does not exceed that considered under the test programs.

The overall conclusion from analyses of structural limit states is that limit state capacity is not degraded when small amounts of ASR expansion are present in structures. Presently, the ASR expansion levels in Seabrook structures are below the levels at which limit state capacities are reduced.

One of the objectives of the test program was to identify effective methods for monitoring ASR. The program concluded that monitoring the in-plane and through-thickness expansion is effective for characterizing the significance of ASR in structures. A Combined Cracking Index (CCI) methodology based on crack width summation was shown to be effective for in-plane expansion monitoring. Snap ring borehole extensometers (SRBEs) provided accurate and reliable measurements for monitoring through-thickness expansion.

Results from the large-scale testing program are also used to support evaluations of structures subjected to deformation. These evaluations are discussed in the Building Deformation Monitoring Program in LRA Section B.2.1.31B.

PROGRAM ELEMENTS

The following provides the results of the evaluation of each program element against the 10 elements described in Appendix A of NUREG-1800 Rev. 1, *"Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants"*.

ELEMENT 1 - Scope of Program

The Seabrook Station Alkali-Silica Reaction (ASR) Monitoring Program provides for management of aging effects due to the presence of ASR. Program scope includes concrete structures within the scope of the License Renewal Structures Monitoring Program ***and License Renewal ASME Section XI Subsection IWL Program.*** License Renewal concrete structures within the scope of this program include:

Category I Structures

- Containment Building (including equipment hatch missile shield)
- Containment Enclosure Building
- Containment Enclosure Ventilation Area
- Service Water Cooling Tower including Switchgear Rooms
- Control Building
- Control Building Make-up Air Intake Structures
- Diesel Generator Building
- Piping (RCA) Tunnels
- Main Steam and Feed Water East and West Pipe Chase
- Waste Processing Building
- Tank Farm
- Condensate Storage Tank Enclosure
- Emergency Feed Water Pump House Building, including Electrical Cable Tunnels and Penetration Areas (Control Building to Containment)
- Fuel Storage Building
- Primary Auxiliary Building including RHR Vaults
- Service Water Pump House
- Service Water Access (Inspection) Vault
- Circulating Water Pump House Building (below elevation 21'-0)
- Safety Related Electrical Manholes and Duct Banks
- Pre-Action Valve Building

Miscellaneous Non-Category I Yard Structures

- SBO Structure – Transformers and Switch Yard foundations
- Non-Safety-Related Electrical Cable Manhole, Duct Bank Yard Structures foundations
- Switchyard and 345 KV Power Transmission foundations

Non-Category I Structures

- Turbine Generator Building
- Fire Pump House
- Aboveground Exterior Tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B and 1-FP-TK-29 foundations
- Fire Pump House Boiler Building
- Non-Essential Switchgear Building
- Steam Generator Blowdown Recovery Building
- Intake & Discharge Transition Structures

ELEMENT 2 - Preventive Actions

There are no preventive actions specified in the Seabrook Station Structures Monitoring Program, which includes implementation of NUREG-1801 XI.S5, XI.S6, and XI.S7. These are monitoring programs only. Similarly, the ASR Monitoring Program does not rely on preventive actions.

ELEMENT 3 - Parameters Monitored/Inspected

The Alkali-Silica Reaction (ASR) Monitoring Program manages the effects of cracking due to expansion and reaction with aggregates. The potential impact of ASR on the structural performance and anchorage capacity of concrete is a consequence of strains resulting from the expansive gel. The strains consequently produce the associated cracking.

The program focuses on identifying evidence of ASR, which could lead to expansion due to the reaction with aggregates. The program reflects published guidance for condition assessment of structures and incorporates practices consistent with those used as part of the large-scale testing programs.

Initial screening of ASR

Walkdowns of the station are performed on a periodic basis (SMP walkdowns, Systems Walkdowns, etc.). Visual symptoms of deterioration are noted and compared to those commonly observed on structures affected by ASR. Common visual symptoms of ASR include, but are not limited to, "map" or "pattern" cracking and surface discoloration of the cement paste surrounding the cracks. The cracking is typically accompanied by the presence of moisture and efflorescence. The lists of symptoms associated with the initial screening of ASR is consistent with many published documents, including but not limited to the Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures", and the Institution of Structural Engineering document "Structural Effects of Alkali-Silica Reaction: Technical Guidance on the Appraisal of Existing Structures."

Inspection of inaccessible areas of concrete will be performed during opportunistic or focused inspections for buried concrete performed under the Maintenance Rule every 5 years. The concrete materials used to produce the concrete placed in inaccessible areas were the same as the concrete materials used to produce the concrete placed in accessible areas. Thus, the performance and aging of inaccessible concrete would be the same as the performance and aging of accessible concrete.
Since the concrete mix and aggregates used at Seabrook Station is consistent between structures it is assumed unless demonstrated otherwise that ASR can be present. Petrographic examination can be performed on a concrete specimen to aid in confirming the proposed diagnosis arrived upon from visual inspection of the concrete surface. Typical petrographic features of ASR generally consist of the following:

- Micro-cracking in the aggregates and/or cement paste
- Reaction rims around the aggregates.
- Silica gel filling cracks or voids in the sample.
- Loss of cement paste-aggregate bond.

Expansion

For ASR-affected surfaces at Seabrook Station, NextEra Energy Seabrook will monitor the effects of ASR expansion by obtaining measurements in both the in-plane (X&Y directions) and through-thickness directions (Z-direction). Specifically, Seabrook will be monitoring the Combined Cracking Index (CCI) for in-plane expansion and extensometer measurements for through-thickness expansion. Expansion from ASR results in cracking and a change to the material properties of the concrete, and eventually requires an evaluation to ensure adequate structural performance.

Expansion is a readily quantifiable parameter and an effective method for determining ASR progression. Expansion measurements at Seabrook can be easily obtained in the in-plane directions. The Cracking Index (CI) is a quantitative assessment of cracking present in the cover concrete of affected structures. A CI measurement is taken on accessible surfaces exhibiting the typical ASR symptoms. The CI is the summation of the crack widths on the horizontal or vertical sides of a section of the ASR-affected concrete surface of predefined dimensions. Seabrook uses a grid size of 20 inches by 30 inches. The CI in a given direction is converted and reported in units of mm/m.

The CIs are used to establish the Combined Cracking Index (CCI). The CCI estimates expansion on a concrete surface using measurements of crack widths along a pre-determined length or grid. The CCI is calculated by summing the crack widths crossing all reference grid lines and dividing the result by the sum of all gridline lengths. Criteria used in assessment of expansion is expressed in terms of CCI and based on recommendations provided in MPR-3727, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments" and supported by the test programs. The test programs indicated that direction of expansion is not significantly affected by the reinforcement when expansion is at or below approximately 1 mm/m. Beyond this expansion level, the two-dimensional reinforcement mats provide confinement in the in-plane directions, and through-thickness expansion dominates.

Data analysis from the large-scale test program has been completed and thresholds established based on the test reports. The thresholds are based on the structure as a whole so if localized extensive ASR or macro cracking is experienced in particular areas of the structure, then the entire structure is assumed to be susceptible to similar degradation. The overall methodology for using in-plane and through-thickness expansion values for various aspects of the monitoring program is summarized as follows:

Initial screening for ASR will be performed using CCI only. CCI values exceeding 1 mm/m will trigger additional actions. CCI is a relatively simple, non-destructive method for monitoring cracking that appropriately characterizes expansion until expansion reorients in the direction of least restraint (i.e., the through-thickness direction at Seabrook Station).

Anchor Performance Monitoring Parameter

For anchor performance, the large scale test programs show that ASR does not have an effect until in-plane expansion reaches a sufficiently high level. Therefore, if the CCI exceeds a specified threshold, additional evaluation must be performed to justify continued acceptability of the anchors.

This approach is based on the fact that anchor performance is sensitive to in-plane expansion, but not through-thickness expansion. In-plane expansion creates micro-cracks parallel to the axis of an anchor, mainly in the concrete cover. These micro-cracks perpendicular to the concrete surface have the potential to provide a preferential failure path within a potential breakout cone, leading to degraded anchor performance.

Through-thickness expansion has the potential to create micro-cracks perpendicular to the axis of an anchor. These potential micro-cracks that open parallel to the concrete surface do not provide a preferential failure path to result in degraded anchor performance. An anchor loaded in tension would compress the through-thickness expansion and close any potential micro-cracks within the area of influence of that anchor. Without a 'short-circuit' of the breakout cone, through-thickness expansion is a non-factor in anchor performance.

Crack Width Summation

Crack width summation is a simple methodology for initial assessment of ASR-affected components and is recommended by publicly available resources.
ASR produces a gel that expands as it absorbs moisture. This expansion exerts a tensile stress on the surrounding concrete which strains the concrete and eventually results in cracking.

The engineering strain in a structural member at the time of crack initiation (ε_{cr}) is equivalent to the tensile strength of the concrete divided by the elastic modulus ($\varepsilon_{cr} = \sigma_t / E$). The Cracking Index quantifies the extent of the surface cracking. The total strain in the concrete can be approximated as the sum of the strain at crack initiation plus the cracking index ($\varepsilon \approx \varepsilon_{cr}$ + CI). Figure 1 depicts a concrete specimen with rebar being put in tension resulting in cracking.

Concrete has little strain capacity; therefore, in ASR-affected concrete, the crack widths comprise most of the expansion (ΔL). As a result, the Cracking Index provides a reasonable approximation of the total strain applied to the concrete after crack initiation, because strain in the un-cracked concrete between cracks is minimal.

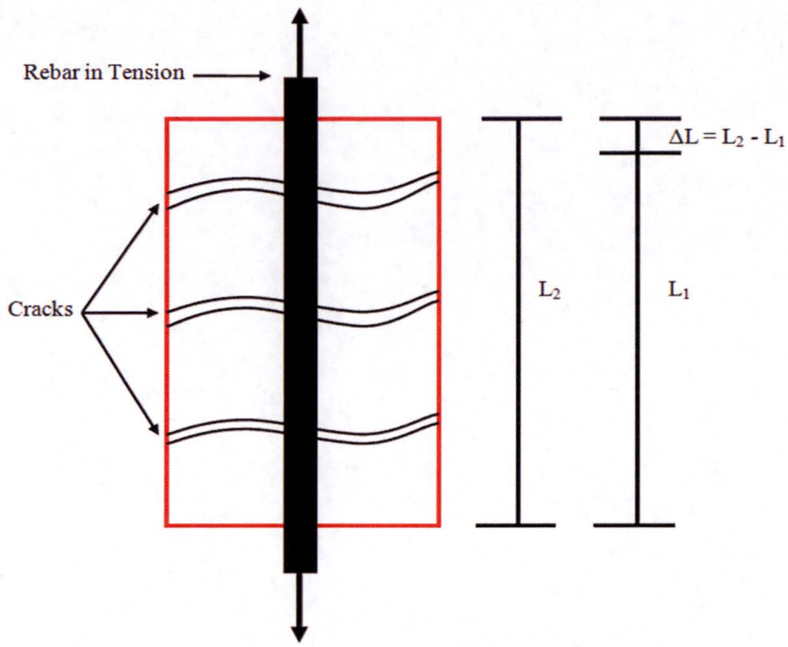


Figure 1 - Concrete Specimen put in Tension

For surfaces where horizontal and vertical cracking indices are similar (e.g., where there is equivalent reinforcement in both directions), a Combined Cracking Index (CCI) that averages the horizontal and vertical Cracking Indices can consolidate the expansion assessment to a single parameter. The CCI is also used to measure the effects of associated rebar strain.

Change in Elastic Modulus and Extensometer Measurements

The large scale test program shows that out-of-plane expansion dominates for structures with two-dimensional reinforcement mats (like seen at Seabrook Station).

Data from the structural testing programs have shown that expansion in the in-plane direction plateaus at low expansion levels, while expansion in the through-thickness direction continues to increase. Seabrook will install the extensometers in Tier 3 and other selected locations to measure expansion in the through-thickness direction. This approach will enable measuring expansion for a given concrete structural member from the time the extensometer is installed and going forward. To calculate the total expansion, Seabrook will determine expansion from original construction until the time the extensometers are installed (pre-instrument + extensometer measurements).

The method to determine the total ASR induced through-thickness expansion at each instrument location at Seabrook is to use a determined pre-instrument expansion based on the reduction in modulus of elasticity.

A correlation relating expansion to reduction in elastic modulus was developed from the large scale testing program data. ~~The~~ ***This*** correlation ~~relating expansion to reduction in elastic modulus~~ is applicable to reinforced concrete structures at Seabrook. The elastic modulus was chosen because the large scale test program showed it to be the most sensitive and most repeatable material property. The test data used to generate the correlation were obtained from the test specimens that were designed to be as representative as practical of the concrete at Seabrook, including the reinforcement detailing. Additionally, comparison against literature data shows that the correlation follows a trend that is consistent with other published studies.

The extensometer measurements will provide direct measurements of through-thickness expansion going forward~~s~~. The measurements are the parameter to be monitored. The elastic modulus will not be monitored going forward; Pre-instrument expansion is calculated initially to establish expansion to date and is not repeated.

Structural Limit States

The applicable design codes provide methodologies to calculate structural capacities for the various limit states and loading conditions applicable to Seabrook Station. Each relevant limit state was evaluated using published literature and the results of the MPR/FSEL large-scale test programs that used specimens designed and fabricated to represent reinforced concrete at Seabrook Station. The following guidance applies for structural evaluations of ASR-affected concrete structures at Seabrook Station:

- <u>Flexure/Reinforcement Anchorage</u> - Based on the MPR/FSEL large-scale test program results, structural evaluations should consider that there has been no adverse impact on flexural capacity and reinforcement anchorage (development length) performance, provided that through-thickness expansion is at or below bounding conditions of the large scale testing and expansion behavior is comparable to the test specimens.

- <u>Shear</u> – Based on the MPR/FSEL large-scale test program results, structural evaluations should consider that there has been no adverse impact on shear capacity, provided that through-thickness expansion is at or below bounding conditions of the large scale testing and expansion behavior is comparable to the test specimens.

- Anchors and Embedments – Based on the MPR/FSEL large-scale test program results, structural evaluations should consider that there is no adverse effect to post-installed or cast in place anchor/embedment capacity, provided that in-plane expansions remain at or below limits established by large scale testing. Through-thickness expansion is not relevant for anchor/embedment capacity.

ELEMENT 4 - Detection of Aging Effects

Monitoring walkdowns are performed on a periodic basis. The ~~Structural~~ ***Structures*** Monitoring Program (SMP) walkdowns identify areas that show symptoms of ASR being present. The SMP includes periodic visual inspection of structures and components for the detection of aging effects specific for that structure. The inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found. A structure found in a harsh environment is defined as one that is in an area that is subject to outside ambient conditions, very high temperature, high moisture or humidity, frequently large cycling of temperatures, frequent exposure to caustic materials, or extremely high radiation levels. For structures in these harsh environments, the inspection is conducted on a five (5) year basis (plus or minus one year due to outage schedule and two inspections within ten years. Structures not located in an area qualifying as a harsh environment are classified as being in a mild environment, and are inspected on a ten (10) year basis (plus or minus one year due to outage schedule and two inspections within twenty years).

In-Plane Expansion

As previously discussed in Element 3, Seabrook uses the CCI methodology to monitor the expansion of ASR affected areas in the in-plane direction. A CCI is established at thresholds at which structural evaluation is necessary. The CCI of less than 1.0 mm/m can be deemed acceptable with deficiencies (Tier 2). Deficiencies determined to be acceptable with further review are trended for evidence of further degradation. A CCI of 1.0 mm/m or greater requires structural evaluation (Tier 3). All locations meeting Tier 3 will be monitored via CCI on a ½ year (6-month) inspection frequency. All locations meeting Tier 2 will be monitored on a 2.5 year (30-month) frequency. In the event ASR monitoring results indicate a need to amend either the monitoring program acceptance criteria or the frequency of monitoring, NextEra Energy Seabrook will take such action under the Operating Experience element of the Alkali-Silica Reaction Monitoring Program.

Seabrook has established reference grids that track the CCI of ASR affected areas. These grids are 20" x 30" and consist of three parallel vertical lines and two parallel horizontal lines. Measurement referenced points (gage points) are installed at the intersections of horizontal and vertical lines of the reference grid to allow for long-term monitoring of potential ongoing expansion. The CI is obtained from measurements of crack widths along a set of lines drawn on the surface of a concrete member. Expansion is documented by measuring the increase in the length of the lines used to determine the CI (distance between gage points). A pocket-size crack comparator card and an optical comparator are used to take the measurements.

The location of the CCI reference grid is established in the area that appears to exhibit the most-severe deterioration due to ASR (accessibility and structure geometry also factor into the decision making progress on where to establish a grid). At Seabrook the axes of the reference grid/grids are parallel and perpendicular to the main reinforcement of the associated reinforced concrete member.

CCI correlates well with strain in the in-plane directions and the ability to visually detect cracking in exposed surfaces making it an effective initial detection parameter. CCI's limitation for heavily reinforced structures is that in-plane expansion (and therefore CCI) has been observed to plateau at a relatively low level of accumulated strain in test specimens from the ***MPR/FSEL*** large scale testing program***s***. No structural impacts from ASR have been seen at these plateau levels in the large scale testing program. While CCI remains useful for the detection and monitoring of ASR at the initial stages, an additional monitoring parameter in the out-of-plane direction is required to monitor more advanced ASR progression. The difference between the in-plane expansion and the through-thickness expansion is due to the reinforcement detailing and the resulting difference in confinement between the in-plane and through-thickness direction. Through thickness expansion is less confined due to the fact that there is no reinforcement in that direction, therefore, expansion occurs preferentially in the through-thickness direction. Similarly, for unreinforced concrete backfill, expansion occurs in all directions.

Out-of- Plane Expansion

The need for out-of-plane expansion monitoring is triggered by a CCI exceeding 1 mm/m. The expansions of the test specimens ***in*** ~~fabricated and tested at Ferguson Structural Engineering Laboratory (FSEL), at The University of Texas at Austin,~~ ***the MPR/FSEL large-scale test programs*** were significantly more pronounced in the through-thickness direction (i.e. perpendicular to the reinforcement mats) than the in-plane directions (i.e. on the faces of the specimens parallel to the reinforcement mats).

Elastic Modulus

To determine expansion to date at a location selected for instrument installation, Seabrook will be removing concrete cores at the location in which the instruments will be installed and testing them for compressive strength and elastic modulus. Using the methodology from MPR-4153, the elastic modulus values will be used to determine pre-instrument expansion in the through-thickness direction.

Concrete cores will be removed from all Tier 3 locations for material property testing. Cores removed for property testing will have the approximate dimensions of 4" diameter × 8" length and will be tested in accordance with ASTM C39 for Compressive Strength and C469 for Elastic Modulus. The cores will be taken perpendicular to the reinforcement mat.

A visual examination of the cores will confirm there is no mid-plane crack or edge-effect cracking.

Snap-Ring Borehole Extensometer

Seabrook will install Snap-Ring Borehole Extensometers (SRBEs) at the station to monitor through-thickness expansion. The Large Scale Testing Program evaluated performance of the SRBEs, along with two other instrument types, in a test specimen representative of the concrete at Seabrook Station over a one-year period. The SRBE provided accurate measurements of through-thickness expansion throughout the test program and did not exhibit any problems related to reliability. The test program involved cycles of extended exposure to high temperature and humidity, which bounds the conditions expected at Seabrook Station.

The SRBE consists of a graphite rod that is held in place by an anchor placed in the borehole. Measurements are performed by using a depth micrometer to measure the distance from a reference anchor at the surface of the concrete to the end of the graphite rod. The SRBE design contains no electronics and does not require calibration. Therefore, failure of the SRBE is unlikely. In the event that an SRBE did fail (e.g., an anchor broke loose), Seabrook could install another SRBE nearby to the failed location and continue expansion monitoring. This will not result in significant loss of data.

A SRBE will be installed in a core bore at each Tier 3 location. The elastic modulus will only be determined at the time of core removal to determine pre-instrument expansion to date. Additionally, mid-plane or edge-effect cracking will be visually observed at the time of core removal. ***SRBE monitoring will be conducted on a six month frequency.***

ELEMENT 5 - Monitoring and Trending

The progression of ASR degradation of the concrete is an important consideration for assessing the long term implications of ASR and specifying monitoring intervals. The most reliable means for establishing the progression of ASR degradation is to monitor expansion of the *in situ* concrete. Results of walkdowns are initially reviewed by a licensed Professional Engineer (PE) or qualified person to determine whether the symptoms shown have potential to be ASR and if CCI measurements are needed.

In-Plane and Out-of-Plane Expansion

For anchor capacity, shear capacity, and reinforcement anchorage, use in-plane expansion (CCI) and out-of-plane expansion (modulus + SRBE measurements) to compare with the test results from the Large Scale Testing program.

ASR is a slow progressing phenomenon. Seabrook will consider the rate at which a location is approaching the CCI and expansion limits and take appropriate action to ensure continued structural adequacy.

ELEMENT 6 - Acceptance Criteria

Identification of the typical symptoms indicative of ASR generates the need to initially start monitoring the area using CCI. For the structures subject to ASR monitoring, rebar strain as a result of ASR induced stresses and ASR induced stresses in combination with design bases loads will be verified to be within code allowable limits.

In-Plane

A Combined Cracking Index (CCI) is established at thresholds at which structural evaluation is necessary (see table below). The Cracking Index (CI) is the summation of the crack widths on the horizontal or vertical sides of 20-inch by 30-inch grid on the ASR-affected concrete surface. The horizontal and vertical

Cracking Indices are averaged to obtain a Combined Cracking Index (CCI) for each area of interest. A CCI of less than the 1.0 mm/m can be deemed acceptable with deficiencies (Tier 2). Deficiencies determined to be acceptable with further review are trended for evidence of further degradation. The change from qualitative monitoring to quantitative monitoring occurs when the Cracking Index (CI) of the pattern cracking equals or is greater than 0.5 mm/m in the vertical and horizontal directions. Concrete crack widths less than 0.05 mm cannot be accurately measured and reliably repeated with standard, visual inspection equipment. A CCI of 1.0 mm/m or greater requires structural evaluation (Tier 3). All locations meeting Tier 3 criteria will be monitored via CCI ***(in-plane expansion) and borehole extensometers (through-thickness expansion)*** on a ½ year (6-month) inspection ~~frequency and added to the through-thickness expansion monitoring via extensometers~~. All locations meeting the Tier 2 structures monitoring criteria will be monitored on a 2.5 year (30-month) frequency. CCI correlates well with strain in the in-plane directions and the ability to visually detect cracking in exposed surfaces making it an effective initial detection parameter. Tier 1 structures do not display signs of ASR and are monitored consistent with the Structures Monitoring Program. In the event ASR monitoring results indicate a need to amend either the monitoring program acceptance criteria or the frequency of monitoring, NextEra Energy Seabrook will take such action under the Operating Experience element of the Alkali-Silica Reaction Monitoring Program.

Tier	**Structures Monitoring Program Category**	**Recommendation for Individual Concrete Components**	**Criteria**
3	Unacceptable (requires further evaluation)	• Structural Evaluation • Implement enhanced ASR monitoring, such as through-wall expansion monitoring using Extensometers.	1.0 mm/m or greater Combined Cracking Index (CCI)
2	Acceptable with Deficiencies	Quantitative Monitoring and Trending	• 0.5 mm/m or greater CCI • CI of greater less than 0.5 mm/m in the vertical and horizontal directions.
		Qualitative Monitoring	Any area with visual presence of ASR (as defined in FHWA-HIF-12-022) accompanied by a CI of less than 0.5 mm/m in the vertical and horizontal directions.

1	Acceptable	Routine inspection as prescribed by the Structural Monitoring Program	Area has no indications of pattern cracking or water ingress. No visual symptoms of ASR.

Criterion of 1mm/m distinguishes between Tier 2 and Tier 3 locations in relation to CCI. The large scale test program shows agreement between embedded pins and CCI, therefore ensuring CCI is acceptable. A structural evaluation is needed when the CCI reaches what is classified as Tier 3 (CCI > 1 mm/m). ***The structural evaluation should reflect the current expansion levels of the structure.***

For ASR-affected structures within the scope of the Building Deformation AMP, the structural evaluation for building deformation fulfills the requirement in the ASR AMP for structural evaluation of Tier 3 structures. For ASR-affected structures that are within the scope of the ASR AMP but not within the scope of the Building Deformation AMP, a structural evaluation that considers the effects of ASR may not exist at the time it reaches Tier 3. In such cases, it will be necessary to perform the evaluation.

If a structural evaluation has already been performed to evaluate building deformation, plant personnel will verify that the in-plane expansion included in the structural evaluation bounds the as-found condition. If necessary, the existing evaluation will be updated to bound the as-found condition and provide margin for future expansion.

It is noted that the Tiers are intended for (1) initial screening of structures, (2) determination of when to install extensometers, and (3) determination of the base monitoring frequency.

Once a structural evaluation is performed for building deformation, the monitoring frequency will be established based on the most stringent criteria. For example a Stage 2 Building Deformation Evaluation that is monitored on a 30 month frequency may have Tier 3 CCI location monitored on a six month frequency and a Stage 3 Building Evaluation that is monitored on a 6 month frequency may have Tier 2 CCI locations that will also be monitored on a 6 month frequency.

Out-of-Plane

In areas in which the CCI is classified as Tier 3 the expansion due to ASR will be monitored in the through-thickness direction as well. Specific acceptance criteria have been established by the large scale test program test reports, and are summarized in the Table below. Maintaining these limits is assured by periodically measuring through-thickness expansion in areas affected by ASR.

Effect of ASR on Structural Limit States

Structural Design Issue	**Criteria[4]**
Flexure & reinforcement anchorage	See FP#101020 - Section 2.1 ***for through-thickness expansion limit***
Shear	See FP#101020 - Section 2.1 ***for through-thickness expansion limit***
Anchor bolts and structural attachments	See FP#101020 - Section 2.1 ***for in-plane expansion limit***

ELEMENT 7 - Corrective Actions

Evaluations will be performed under the Seabrook Corrective Action Program (CAP) and an appropriate analysis will be performed to evaluate against the design basis of that structure. The NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 7 Corrective Actions.

ELEMENT 8 - Confirmation Process

The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 8 Confirmation Process.

ELEMENT 9 - Administrative Controls

The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 9 Administrative Controls.

[4] Expansion Limit Criteria is considered proprietary to NextEra EnerySeabrook. FP #101020 MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," July 2016, was previously submitted to the NRC in SBL-L-16071; License Amendment Request 16-03; Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I; Structures with Concrete Affected by Alkali-Silica Reaction; Dated August 1, 2016

ELEMENT 10 - Operating Experience

The primary source of OE, both industry and plant specific, was the Seabrook Station Corrective Action Program documentation. The Seabrook Station Corrective Action Program is used to document review of relevant external OE including INPO documents, NRC communications and Westinghouse documents, and plant specific OE including corrective actions, maintenance work, orders generated in response to a structure, system or component deficiencies, system and program health reports, self-assessment reports and NRC and INPO inspection reports.

Newly Identified Operating Experience (OE)

Seabrook will update the Aging Management Program for any new plant-specific or industry OE. This includes ongoing industry studies performed both nationally and internationally. Research data taken from these studies will be used to enhance the ASR program, if applicable. In addition NextEra Seabrook has submitted a License Amendment Request to the Commission in accordance with 10CFR50.90 to incorporate a revised methodology related to ASR material properties and building deformation analysis for review and approval. NextEra will incorporate changes related to this LAR submittal as necessary to maintain alignment of the aging management program to the current license basis.

Groundwater Operating Experience

Historically, NextEra Energy Seabrook has experienced groundwater infiltration through cracks, capillaries, pore spaces, seismic isolation joints, and construction joints in the below grade walls of concrete structures. Some of these areas have shown signs of leaching, cracking, and efflorescence on the concrete due to the infiltration. During the early 1990's an evaluation was conducted to assess the effect of the groundwater infiltration on the serviceability of the concrete walls. That evaluation concluded that there would be no deleterious effect, based on the design and placement of the concrete and on the non-aggressive nature of the groundwater.

In 2009, NextEra tested seasonal groundwater samples to support the development of a License Renewal Application. The results showed some of the groundwater to be aggressive. Ground water testing performed in November 2008 and September 2009 found pH values between 6.01 and 7.51, chloride values between 19 ppm and 3900 ppm, and sulfate values between 10 ppm and 100 ppm. Aggressive chemical attack becomes a concern when environmental conditions exceed threshold values (Chlorides > 500 ppm, Sulfates >1500 ppm, or pH < 5.5). Based on determination of aggressive ground water and observed efflorescence on the concrete surface, NextEra initiated a comprehensive review of possible effects to concrete of in-scope structures.

ASR Identification OE

In 2009, NextEra performed a qualitative walkdown of plant structures and the "B" Electrical Tunnel was identified as showing the most severe indications of groundwater infiltration. Concrete core samples from this area were removed, tested for compressive strength and modulus of elasticity, and subjected to petrographic examinations. The results showed that both compressive strength and modulus of elasticity were less than the expected values, which is symptomatic of ASR. The results of the petrographic examinations also showed that the samples had experienced Alkali-Silica Reaction (ASR).

NextEra initiated an extent of condition evaluation and concrete core samples were taken from five additional areas of the plant that showed characteristics with the greatest similarity to the "B" Electrical Tunnel. Additional concrete core samples were also taken from an expanded area around the original concrete core samples in the "B" Electrical Tunnel.

Tests on these core samples confirmed that the original "B" Electrical Tunnel core samples show the most significant ASR. For the five additional areas under investigation, final results of compressive strength and modulus testing indicate that the compressive strength in all areas is greater than the strength required by the design of the structures. Modulus of elasticity was in the range of the expected value except for the Diesel Generator, Containment Enclosure Buildings, Emergency Feedwater Pumphouse, and the Equipment Vaults, which were less than the expected value in localized areas.

Evaluation of the affected structures concluded that they are fully capable of performing their safety function but margin had been reduced. Material property results from cores removed from a reinforced concrete structure do not properly represent the actual structural performance because the structural context is lost. However, the areas are potentially subject to further degradation of material properties due to the effects of ASR.

Confirmation of Overall Expansion Behavior

Seabrook will perform several actions to confirm that expansion behavior at the plant is consistent with the specimens from the MPR/FSEL Large Scale Test Programs. These actions assess similarity of expansion behavior in terms of trends between directions and expansion levels (in-plane, through-thickness, volumetric). The actions also include corroborating the correlation of normalized modulus versus through-thickness expansion derived from the MPR/FSEL testing against

plant data. This AMP may be updated as necessary to account for any findings from these checks, which are described in the table below.

Objective	*Approach*	*When*
Ongoing Monitoring		
Expansion within limits from test programs	*Compare measured in-plane expansion ($\mathcal{E}_{xy}$) and through-thickness expansion ($\mathcal{E}_z$) at the plant to limits from test programs*	*Intervals as specified in AMP*
Lack of mid-plane crack	*Inspect cores removed from ASR-affected structures (and boreholes) for evidence of mid-plane cracks*	*When cores are removed to install extensometers or for other reasons.*
Periodic Confirmation of Expansion Behavior		
Lack of mid-plane crack	*Review of records for cores removed to date or since last assessment*	*Periodic assessments* • *At least 5 years prior to the Period of Extended Operations (PEO)* • *Every 10 years thereafter*
Expansion initially similar in all directions but becomes preferential in z-direction	*Compare $\mathcal{E}_{xy}$ to $\mathcal{E}_z$ using a plot of $\mathcal{E}_z$ versus Combined Cracking Index (CCI)*	
Expansions within range observed in test programs	*Compare measured $\mathcal{E}_{xy}$ and $\mathcal{E}_z$ at the plant to limits from test programs to check margin for future expansion*	
	Compare measured volumetric expansion to range from beam test programs and check margin for future expansion	
Corroborate modulus-expansion correlation with plant data	*For 3 extensometer locations with pre-instrument $\mathcal{E}_z$ in the observed expansion range:* • *Remove cores for modulus testing at extensometer locations with more significant changes in extensometer readings.* • *Compare $\Delta\mathcal{E}_z$ determined from the modulus-expansion correlation with $\Delta\mathcal{E}_z$ determined from the extensometer*	*At least 2 years prior to PEO*

EXCEPTIONS TO NUREG-1800

None

ENHANCEMENTS

- Implement the Alkali-Silica Reaction (ASR) Monitoring
- Revise the Seabrook Structural Monitoring Procedure EDS 36180 to include Alkali-silica reaction description, aging effects, inspection criteria, acceptance criteria.
- Revise the Seabrook ASME Section XI, Subsection IWL Program ES1807.031 to include Alkali-silica reaction aging effects.

CONCLUSION

To manage the aging effects of cracking due to expansion and reaction with aggregates in concrete structures, the existing Structures Monitoring Program, B.2.1.31, and ASME Section XI, Subsection IWL Program, B.2.1.28 have been augmented by this plant specific Alkali-Silica Reaction (ASR) Monitoring Program, B.2.1.31A.

Routine inspections are performed by the Structures Monitoring and the ASME Section XI, Subsection IWL Program. Areas that have no visual presence of ASR are considered "acceptable" (Tier 1). An area with a Combined Cracking Index (CCI) of less than 1.0 mm/m is deemed "acceptable with deficiencies" (Tier 2). An area with a CCI of 1.0 mm/m or greater is deemed "unacceptable" and requires further evaluation (Tier 3). In addition, an area that meets Tier 3 requirements will be monitored for through-thickness expansion in addition to CCI.

Evaluations will be performed under the Seabrook Corrective Action Program (CAP) and an appropriate analysis will be performed to evaluate against the design basis of that structure.

The Seabrook Station ASR Monitoring Program provides reasonable assurance that the effects of aging of in-scope concrete structures due to the presence of Alkali-Silica reaction will be managed to ensure the structures continue to perform their intended function consistent with the current licensing basis for the period of extended operation.

B.2.1.31B BUILDING DEFORMATION

PROGRAM DESCRIPTION

The Building Deformation Monitoring Program is a new plant specific program being implemented under the existing Maintenance Rule Structures Monitoring Program. Building Deformation is an aging mechanism that may occur as a result of other aging effects of concrete. Building Deformation at Seabrook is primarily a result of the alkali silica reaction (ASR) described in LRA section B.2.1.31A but can also result from swelling, creep, and shrinkage. Building deformation can cause components within the structures to move such that their intended functions may be impacted.

The Building Deformation Monitoring Program uses visual inspections associated with the Structures Monitoring Program and cracking measurements associated with the Alkali-Silica Reaction program to identify buildings that are experiencing deformation. The first inspection is a baseline to identify areas that are exhibiting surface cracking. The surface cracking will be characterized and analytically documented. This inspection will also identify any local areas that are exhibiting deformation. The extent of surface cracking will be input into an analytical model. This model will determine the extent of building deformation and the frequency of required visual inspections.

For building deformation, location-specific measurements (e.g. via laser target and gap measurements) will be compared against location-specific criteria to evaluate acceptability of the condition.

Structural evaluations will be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained. Evaluations of structures will validate structural performance against the design basis, and may use results from the large-scale test programs, as appropriate.

Evaluations for structural deformation will also consider the impact to functionality of affected systems and components (e.g., conduit expansion joints). NextEra will evaluate the specific circumstances against the design basis of the affected system or component. Structural evaluations will be used to determine whether additional corrective actions (e.g., repairs) to the concrete or components are required. Specific criteria for selecting effective corrective actions will be evaluated on a location-specific basis.

PROGRAM ELEMENTS

The following provides the results of the evaluation of each program element against the 10 elements described in Appendix A of NUREG-1800 Rev. 1, *"Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants"*.

ELEMENT 1 - Scope of Program

The Seabrook Building Deformation Monitoring Program provides for management of the effect of building deformation on ~~Seismic Category 1~~ ***concrete*** structures and associated components within the scope of license renewal. Program scope includes components within the scope of license renewal contained in concrete structures within the scope of the Structures Monitoring Program ***and License Renewal ASME Section XI Subsection IWL Program.*** Concrete structures within the scope of this program include:

Category I Structures

- Containment Building (including equipment hatch missile shield)
- Containment Enclosure Building
- Containment Enclosure Ventilation Area
- Service Water Cooling Tower including Switchgear Rooms
- Control Building
- Control Building Make-up Air Intake Structures
- Diesel Generator Building
- Piping (RCA) Tunnels
- Main Steam and Feed Water East and West Pipe Chase
- Waste Processing Building
- Tank Farm
- Condensate Storage Tank Enclosure
- Emergency Feed Water Pump House Building, including Electrical Cable Tunnels and Penetration Areas (Control Building to Containment)
- Fuel Storage Building
- Primary Auxiliary Building including RHR Vaults
- Service Water Pump House
- Service Water Access (Inspection) Vault
- Circulating Water Pump House Building (below elevation 21'-0)
- Safety Related Electrical Manholes and Duct Banks
- Pre-Action Valve Building

Non-Category I Structures

- ***Intake & Discharge Transition Structure***

ELEMENT 2 - Preventive Actions

There are no preventive actions specified in the Seabrook Station Structures Monitoring Program, which includes implementation of NUREG-1801 XI.S5, XI.S6, and XI.S7. These are monitoring programs only. Similarly, the Building Deformation Monitoring Program does not rely on preventive actions.

ELEMENT 3 - Parameters Monitored/Inspected

A three ~~step~~ ***stage*** process will be used to initially screen for deformation and to analyze the effects on structures for the self-straining loads from ASR expansion, creep, shrinkage, and swelling. Each stage of the process would have increasing levels of rigor. ***The analysis and evaluation of each structure may begin at any of the three stages. If initial review of a structure determines that a structure cannot be qualified in a particular evaluation stage due to high ASR expansion, low margin in the structural design, or any other limitation that excludes the structure form being qualified at that stage; the structure can be evaluated at a higher stage evaluation that employs more rigor. Ultimately the structure is classified according to the stage in which it is qualified to meet the design code requirements and monitored accordingly. For example, a stage 2 structure is qualified using a Stage 2 evaluation and thresholds are monitored to stage 2 thresholds.***

Review, Acquisition, and Assessment of Deformation Data - ***The initial step in the deformation analysis process involves reviewing existing data and performing additional field surveys of structures. Since ASR was initially identified at Seabrook in 2009, NextEra has gathered visual inspection data and obtained ASR expansion measurement data for each structure through the Structures Monitoring Program. Data also were collected in walkdowns to identify potential interactions between deformed structures and plant components. Recently, seismic gap measurements were obtained for building deformation. Collectively, the ASR expansion and building deformation measurement data can be used to analytically determine the deformed shape of each structure.***

NextEra will initially review the data obtained for each structure to determine if additional measurements are needed to characterize the deformed shape of the structure. A review of the structure and associated data determines which of the three stages is appropriate to analyze each structure. The stage of analysis and the amount of field data required for each building depends on the following considerations:

- *The design margins of the undeformed structure when design basis loads are applied;*
- *The locations where design margins are a minimum;*
- *The magnitude of ASR expansion and deformation measured in the structure;*
- *The orientation and complexity of deformation measurements, and;*
- *The complexity of the structure.*

The review of data assesses that there are sufficient data to characterize structure deformation corresponding to the stage of analysis used to evaluate the structure. If the data assessment concludes that more data are necessary to characterize ASR expansion in the structure, then additional data will be obtained in the form of Crack Index (CI) measurements in ASR affected areas, identification/measurements of expansion induced cracks, measurements between points on the structure, and/or measurements relative to adjacent structures (e.g., seismic gap measurements).

The amount of data needed for the analysis increases with the stage of analyses being performed to qualify each structure. The Stage 1 analysis is based on maximum ASR strain measured by Crack Index (CI) measurements performed at locations with most pattern cracking based on visual inspection for a structure or a region of the structure. The amount of CI data that are needed increases when a structure is evaluated for a higher stage of analysis. A Stage 3 analysis includes a sufficient number of CI measurements to accurately calculate the mean ASR strain in a region of a structure. The number of CI measurements for a region will be determined through one of the following approaches:

- *For large regions, a number of CI measurements are selected such that additional CI measurements would not cause a significant change to the computed mean ASR strain.*
- *For small regions, the number of CI measurement grids will be based on the ratio of measured area to the total area.*

  Alternatively, the mean ASR strain can be computed using a smaller number of CI measurements if close-up visual inspection of the region affirms that the collected measurements are representative of the region. A Stage 2 analysis uses a quantity of data that is between those described for Stages 1 and 3. Other data such as seismic gap measurements, displacement, deformations, width of structural cracks (if any), and overall expansion for structure are used with graded approach based on the stage of analysis.

<u>Quantify ASR Demands</u> – A finite element model (FEM) will be developed for Stage 2 or 3 analyses in ANSYS that represents the undeformed shape of each structure. The dimensions of the model will be based on design drawings. The model will include all relevant portions of the structure and its foundation.

ASR expansion is simulated in the FEM by expanding (i.e., straining) the modeled concrete material at locations where evidence of ASR is observed in the actual structure. The magnitude and distribution of the ASR expansion applied to the FEM is selected to match field measurements and observations. Creep, shrinkage, and swelling that have occurred since each structure was erected could also affect building long term deformation. Although the deformation caused by these long-term conditions is small, these mechanisms are considered in each analysis to more accurately quantify the deformation caused by ASR and long-term loadings. Once the creep, shrinkage, swelling, and ASR expansion are applied to the FEM along with the static deadweight of the structure as a body force, a deformed shape is produced. The deformed shape determined from FEM is compared to the various measurements of the actual deformed shape obtained in the Review, Acquisition and Assessment phase.

Because of inhomogeneity of concrete in structures and the level of detail used to model ASR-affected regions, it may be necessary to adjust the concrete expansion imposed in the ASR-affected regions of the model or make refinements to the shape of ASR regions, while remaining consistent with field measurements, to correlate the predicted shape and extent of deformation with the actual measurements from the structure. If the actual deformed shape of a structure differs from the shape simulated by the FEM, then there may be additional loads on the structure that account for the differences. If the deformed structure cannot be accurately predicted using the FEM and the available measurements, additional measurements will be obtained and the process of verifying the deformation analysis model will be repeated.

<u>Analysis of ASR-Impacted Structure</u> – The overall objective of the deformation analysis is to assess each structure's capacity to withstand design basis loads in conjunction with the ASR expansion loads. Once the FEM is verified by comparing the simulated deformations and strains to measurements of the actual structure, the magnitude of ASR expansion in the affected areas of the structure is amplified by a factor to account for potential future ASR expansion. Then the original design load demands are added to ASR load demands based on the load combinations specified in Seabrook UFSAR Tables 3.8-1, 3.8-14, and 3.8-16. In Stage 3 evaluations, the original design demands are recomputed by applying the associated loads to the FEM. In other stages, the original design demands are generally taken from original design

calculations. The results from these analyses are compared to ACI 318-71 or ASME Section III acceptance criteria, as appropriate.

Establish Parameters Monitored and Threshold Limits – ***The specific locations where ASR exists in each structure and the critical areas where the margin to Licensing Basis structural design code and design basis acceptance criteria are most limiting influence the locations and types of measurements that are used to monitor each structure. The results from the deformed structure analysis will be reviewed to identify the critical areas for meeting the structural acceptance and seismic gap criteria and the ASR regions that influence the calculated results in the critical areas. Monitoring parameters will be identified and their locations specified based on the review.***

Field inspections shall be performed to obtain observations and measurements that can be used to quantify ASR loads applied to each structure. A list of observations and measurements that may be recorded during field inspection is provided in Table 1. A document review shall be performed for each structure. Documents that are necessary to review include design drawings and design criteria. Other additional documents shall also be reviewed as needed in order to perform susceptibility evaluations. All documents reviewed shall be the latest available revision. A list of documents that may be reviewed is provided in Table 2.

The number of monitoring locations and the types of measurements taken will be influenced by the sensitivity of the results to the level of expansion or deformation in these regions as well as the size and shape of ASR-affected areas in the structure.

Table 1. Field Observations and Measurements for Deformation Evaluations

	Parameter	Description
	Cracking suspect of ASR (visual observations)	Qualitative visual observations made of cracking that exhibits visual indications of ASR and ASR-related features, using industry guidelines
	Cracking not suspect of ASR (visual observations)	Qualitative visual observations made of cracking that do not exhibit indications of ASR. These cracks may be structural (i.e. caused by stresses acting on the structure) or caused by shrinkage or other mechanisms aside from ASR.
	Other structural or material distress (visual observations)	Qualitative visual observations made of structural distress, such as buckled plates, broken welds, spalled concrete, delaminated concrete, displacement at embedded plates, damage to coatings, and chemical staining.
	Crack index	Quantitative measurement of in-plane cracking on a concrete structural component using the cracking index measurement procedure
	In-plane strain rate	Quantitative measurement of length between two points installed on a concrete component using a removable strain gage. In-plane expansion is computed as the change in length between measurements recorded at different times.
	Through-thickness expansion	Quantitative measurement of the thickness of a concrete component using an extensometer device. Through-thickness expansion is computed as the change in thickness between measurements recorded at different times.
	Through-thickness strain rate	Calculated value based on measurements of through-thickness expansion over a period of time.
	Individual crack widths/lengths	Quantitative measurement of individual crack widths using either a crack card, an optical comparator, or any other instrument of sufficient resolution. Such measurements shall be accompanied by notes, sketches, or photographs that indicate the pattern of the cracks and their length. Also included in this category are tools that quantify the change in crack widths, such as mountable crack gages, extensometers, and invar wires
	Seismic isolation joints	Quantitative measurement of the width of seismic joints that separate two adjacent structures. Also included in this category are qualitative observations of distress in seals covering or filling isolation joints, such as tears, wrinkles, and bubbles.
	Structure dimensions	Quantitative measurement of a structure's dimensions or the distance between two adjacent structures. Included in this category are measurements of plumbness of walls, levelness of slabs, and bowing/bending of members.
	Equipment/conduit offsets	Quantitative measurement or visual observation of building deformation through the misalignment of equipment and/or the deformation of flexible conduit joints.

Table 2. Document Review for Building Deformation Evaluations

		Documents	Description
Review Necessary		Structural design drawings and specifications	Structural design drawings, including excavation drawings, backfill drawings, and adjacent structure drawings as needed
		Original structural design criteria	Structural design criteria, including the Updated Final Safety Analysis Report (UFSAR), documenting loads, load combinations, and strength acceptance criteria for which the structure was originally designed
		Structural design calculations	Structural design calculations documenting the underlying assumptions of the original structural design and original design demands and capacities.
Review As Needed		Construction documentation	Construction documents, drawings, and photos documenting construction stages, concrete placement, etc. This category also includes as-built drawings and survey data following construction.
		Documentation of structural and material tests	Existing documentation of testing, including petrography, that has been performed on the structure or the materials of the structure.

Stage 1 – Susceptibility Screening Evaluation: Each of the seismic Category I structures are screened for susceptibility to structural deformation caused by ASR using existing field data and conservative hand calculations.

Stage 2 – Analytical Evaluation: An analytical evaluation is performed for structures that the Stage 1 Susceptibility Screening Evaluation identifies as susceptible to deformation, but do not satisfy ACI 318-71 acceptance criteria. A finite element model of the structure is used to estimate structural demands due to self-straining loads, while all other demands are taken from existing design calculations. Additional field data is obtained to provide input to the analysis. The evaluation verifies compliance with ACI 318-71 using the same criteria as the original design.

Stage 3 – Detailed Evaluation: A detailed design confirmation calculation is performed when the Stage 2 Analytical Evaluation concludes that some area of a structure does not satisfy ACI 318-71 acceptance criteria or when the structure has sufficient deformation that may impact demands computed in the original design. The detailed evaluation uses the Stage 2 finite element model to compute demands due to self-straining loads as well as all other design loads. In the Stage 3 evaluation, consideration is given to cracked section properties, self-limiting secondary stresses, and the redistribution of structural demands when sufficient ductility is available.

All three stages of the evaluation process use the original design acceptance criteria given in the UFSAR Chapter 3 including separation of structures by seismic gaps. Each analysis stage will determine threshold monitoring limits to define the monitoring frequency and criteria for re-evaluating structures with deformation. The threshold monitoring limits are described below.

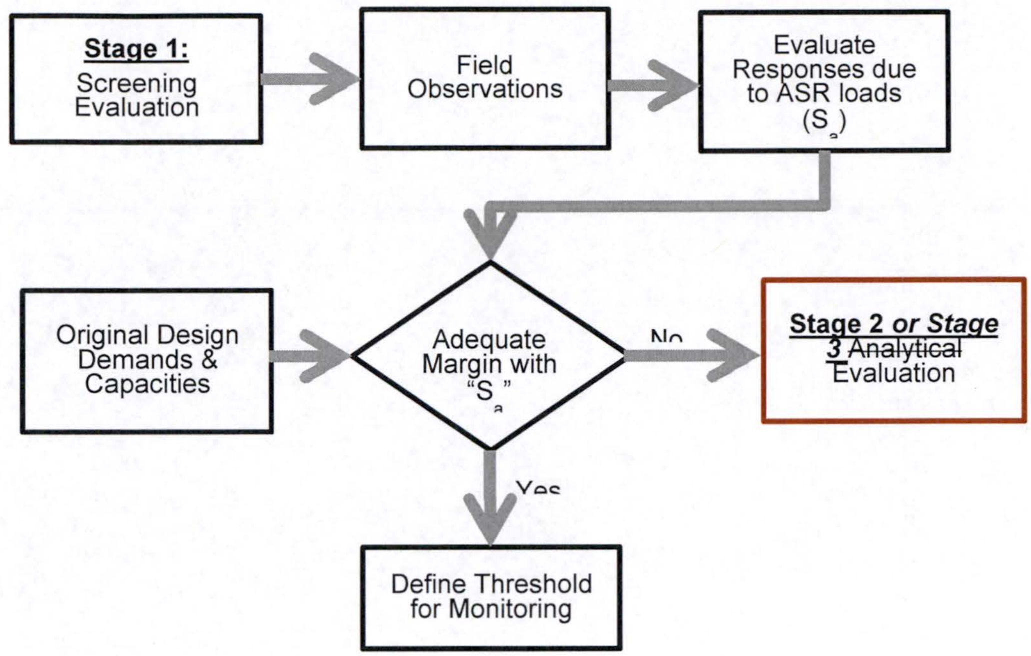
Stage 1: Susceptibility Screening Evaluation

NextEra has conducted walkdowns of selected in scope structures and plant equipment to identify items of interest and evaluate the items through the Corrective Action Program for their impact on plant operations. NextEra will perform future walkdowns for all in scope structures. Inspection data from these walkdowns and other measurements obtained for ASR-affected structures will be reviewed to determine if deformation is occurring and to identify potential locations and directions of movement or deformation. The data that will be collected includes measurements of relative building movements, equipment misalignments, and concrete cracking indexes. ASR monitoring grids, which are used to measure the strain in reinforced concrete, were installed on structures throughout the facility. The monitoring grids were installed at the most severe locations for ASR cracking, and therefore, provide a conservative estimate of the strain in the structure. After reviewing existing field data, a walkthrough inspection will be performed to verify field conditions and determine if ASR expansion only affected localized regions of the structure or whether the structure has experienced global deformation of structural members. ***Field data that are older than three years old shall be verified during this walkthrough inspection.***

In the susceptibility screening process, conservative estimates of deformations and strains based on the field data are used to estimate demands caused by self-straining loads for critical locations in the structure. Self-straining loads include four components: ASR, creep, shrinkage, and swelling. Based on guidance in ACI 318-71, creep, shrinkage and swelling are included with the dead load. The ASR demands (identified as "Sa" herein) are factored and then combined with demands due to design loads for critical load combinations in the current licensing basis. An evaluation is performed using strength acceptance criteria as described in the current licensing basis.

For screening evaluations that conclude a structure fully complies with the strength acceptance criteria, the critical locations of the structure are re-evaluated for a higher level of ASR demand to determine the maximum allowable, factored self-straining loads at which the structure meets the design acceptance criteria. A set of monitoring elements (consisting of strain measurements, deformation measurements, seismic gap measurements, and/or other quantifiable behaviors) is established along with threshold limits for each monitoring element. The threshold limits are defined as the maximum measurement for each monitoring element that results in a factored self-straining load equal to the factored self-straining load at the structural design limit (with factored design basis loads included). The threshold limit for the monitoring elements defined in Stage 1 is equal to the set of monitoring element measurements that produce a factored ASR demand that is 90% of the factored self-straining load at the acceptance limit. If a structure monitoring element measurement obtained from walkdowns and other monitoring activities exceeds the monitoring threshold limit, then a Stage 2 Analytical Evaluation is required.

A structure is classified as Stage 1 if the Susceptibility Screening Evaluation concludes that the structure satisfies the strength acceptance criteria and the structure monitoring element measurements are less than the Stage 1 threshold limits. The Susceptibility Screening Evaluation for Stage 1 structures is summarized in a calculation package that supplements the original design calculation. The calculation package also documents the set of monitoring measurements and the threshold limits for the monitoring process. The monitoring measurements and the threshold limits are incorporated into the Seabrook Structures Monitoring Program to periodically assess the condition of structures and verify that the structure meets the design acceptance criteria.



Stage 2: Analytical Evaluation

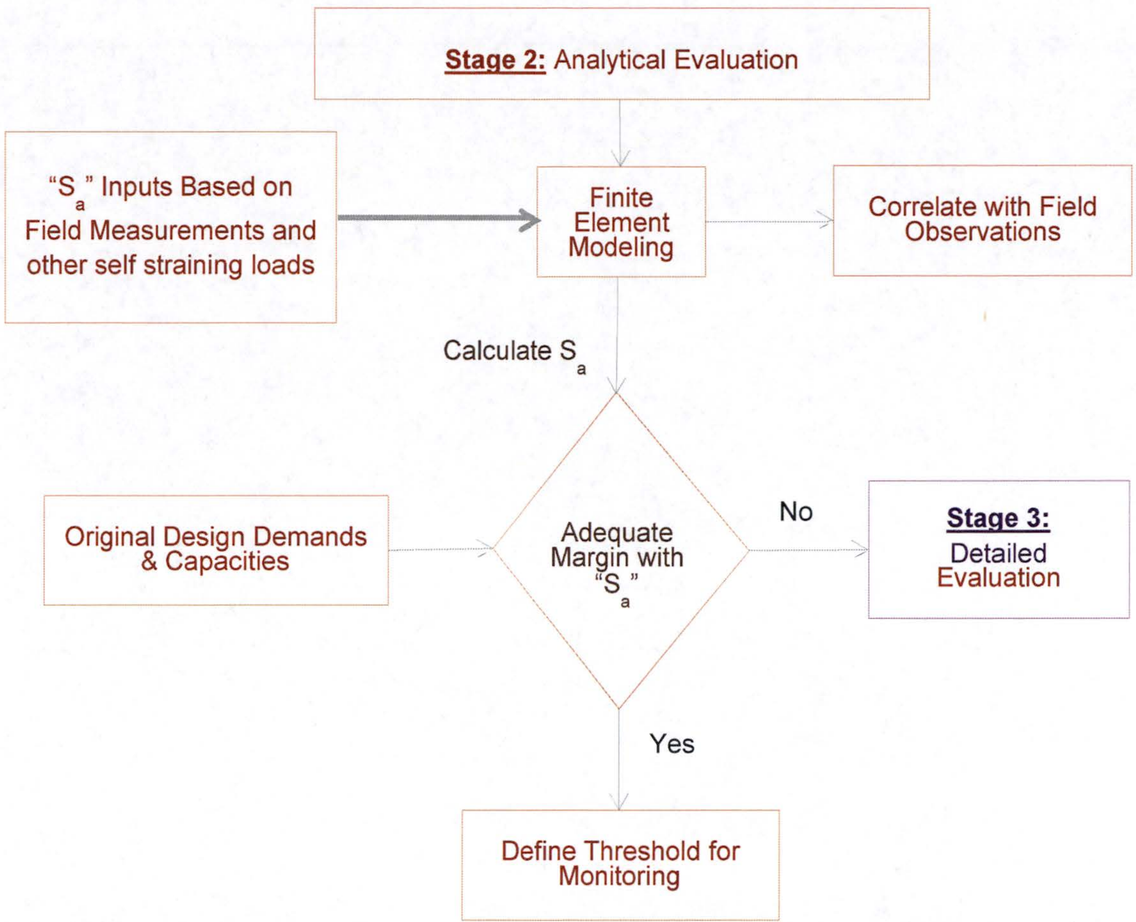
For structures that cannot be shown to meet the ACI 318-71 acceptance criteria using the conservative methods of the Susceptibility Screening Evaluation or monitoring measurements indicate high Sa demands, an Analytical Evaluation is required. The Analytical Evaluation uses more accurate methods to quantify demands due to self-straining loads. Also, additional inspections are performed to measure structural strains and deformations at a broader range of critical locations of the structure. These measurements would be used to compute the self-straining loads with more accuracy than possible using the inputs from the Susceptibility Screening Evaluation process.

An ANSYS finite element model (FEM) of the structure is created based on design drawings and uncracked design section properties. The model is initially benchmarked to the original design analysis of the structure with only the current licensing basis loads. The FEM is then calibrated such that the deformations and strains due to unfactored sustained loads and self-straining loads are consistent with field measurements. The FEM is used to compute the structural demands due to ASR loads (Sa). The self-restraining demands from finite element analysis are factored and then combined with demands due to factored design loads from the original design calculations for the load combinations described in the current licensing basis. The structural demand in critical regions of the structure are evaluated using strength acceptance criteria described in the current licensing basis. The methods used for the

Stage 2 analysis are unchanged from the original design analyses with the exception of accounting for the self-straining loads in the analysis and the use of the ANSYS software program for computing the sustained and self-straining loads.
Structures that satisfy the Analytical Evaluation acceptance criteria are re-evaluated for a higher level of Sa to compute the maximum allowable self-straining loads on the structure. The maximum allowable loads correspond to the maximum, factored self-straining loads at which the structure meets the design acceptance criteria. A set of monitoring measurements are identified and threshold limits are set for each measurement based on the maximum allowable self-straining load. The threshold limits for each monitoring element defined in Stage 2 are determined by scaling all measurements proportionally such that a factored self-restraining demand equal to 95% of the value at the design acceptance limit is achieved.

A structure is classified as Stage 2 if the Analytical Evaluation concludes that the structure satisfies the strength acceptance criteria and the structure monitoring element measurements are less than the Stage 2 threshold limits. The Analytical Evaluation calculation for Stage 2 structures supplements the original design calculation. The monitoring measurements, measuring locations, and threshold limits for monitoring are also included in the supplement to the calculation.

Monitoring elements may include strain measurements, measurements of the relative displacement between structures, component specific measurements (e.g. gap measurements) and other quantifiable parameters. The threshold limits are defined as the maximum allowable measurement for each monitoring parameters that limits the self-straining loads to some fraction of the maximum allowable self-straining load. The monitoring measurements and the threshold limits are used to periodically assess the condition of structures and verify that the structure meets the design acceptance criteria.

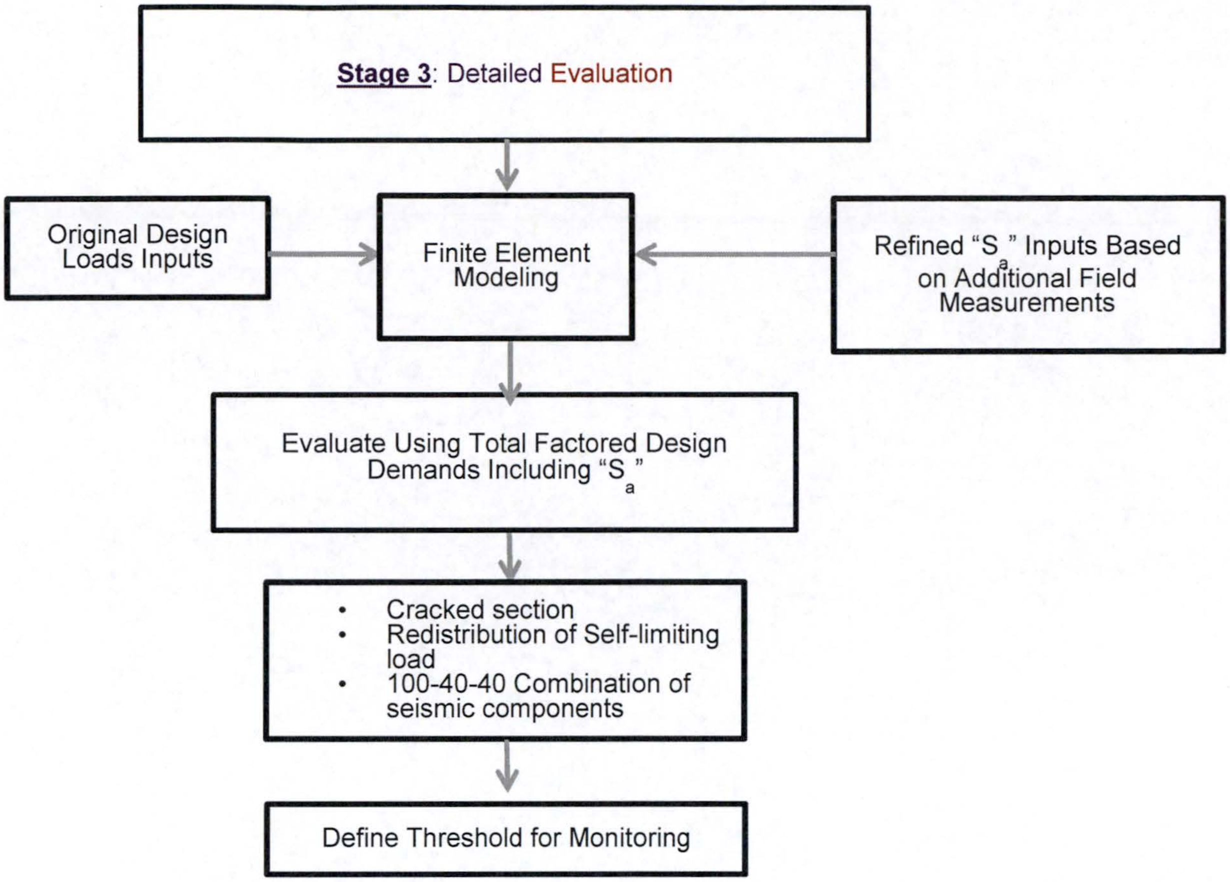


Stage 3: Detailed Evaluation

Structures that do not meet the acceptance criteria of the Stage 2 Analytical Evaluation are analyzed by a Detailed Evaluation. In the Detailed Evaluation, Sa demands and the loads from creep, shrinkage and swelling are recomputed using the Stage 2 FEM. Structural demands due to design loads are recomputed by applying design demands (i.e. wind, seismic, hydrostatic pressure, etc.) to the FEM. A detailed structural evaluation is performed for all load combinations described in the licensing basis. The structure is evaluated using strength acceptance criteria described in the current licensing basis. Consideration is given to force and moment redistribution in regions with localized overstresses and sufficient ductility. In the Stage 3 evaluation, consideration is given to cracked section properties, self-limiting secondary stresses, and the redistribution of structural demands when sufficient ductility is available. The 100-40-40 percent rule in NRC Regulatory Guide 1.92, Revision 3, is used as an alternative to the SRSS method for combining three directional seismic loading in the analysis of seismic, Category I structures that are deformed by the effects of ASR.

Structures that meet the acceptance criteria of the Detailed Evaluation are re-evaluated for a higher level of self-straining load to establish the threshold limits for each monitoring element measurement. A similar process is used as described in the Stage 2 Analytical Evaluation above. The threshold limit for each monitoring element defined in Stage 3 is equal to the limit for the monitoring element measurement that produces a factored Sa load at the design acceptance limit.

The Detailed Evaluation is summarized in a design calculation package that will supersede the original design calculation. The calculation package documents the set of monitoring measurements and the threshold limit of the monitoring measurements for the structures monitoring program to verify that the structure to meets the design acceptance criteria.



Example

An example of the process of determining threshold limits for subsequent monitoring (if required for a particular structure) is described below. For the containment enclosure building, seismic gap measurements and annulus width measurements can be used to monitor deformation of the structure. Specific locations are chosen and threshold limits are set for these locations to ensure license renewal intended functions are met. The calculation of these threshold limits is defined and evaluated using the following equations:

$$\overline{TM} \leq TL$$

$$\overline{TM} = \sum_{i=0}^{n} \left| d_{n,field} - d_{n,design} \right| \times \left(\frac{1}{n}\right)$$

$$TL = \sum_{i=0}^{n} \left[\left| d_{n,baseline} - d_{n,design} \right| \times k_{n,thf} \right] \times \left(\frac{1}{n}\right)$$

$$k_{n,thf} = \frac{d_{n,FEA,1.2}}{d_{n,FEA,baseline}}$$

Where:

$\overline{TM}$ = Average deformation for locations in threshold measurement set

TL = Threshold Limit

n = Number of measurement locations in threshold measurement set

$d_{n,field}$ = Field measurement of threshold measurement n at time of monitoring

$d_{n,design}$ = Design dimension of threshold measurement n

$d_{n,baseline}$ = Field measurement of threshold measurement n at time when TL is established and CEB evaluation is performed

$d_{FEA,1.2}$ = Radial deformation of the CEB at location of threshold measurement n due to unfactored sustained loads plus unfactored self-straining loads with a 1.2 threshold factor

$d_{n,FEA,baseline}$ = Radial deformation of the CEB at location of threshold measurement n due to unfactored sustained loads plus unfactored self-straining loads without threshold factor amplification

For each threshold measurement, a method will be established to perform the measurement in a repeatable way. It is particularly important to perform the measurement in a well-defined location; otherwise, seemingly small deviations in the concrete surfaces can have a significant impact on the repeatability of the threshold measurements. For some of the locations in the containment enclosure building, a repeatable measurement method has already been established and a baseline measurement has been obtained. Other locations have been measured in the past, but have not been measured in a suitably repeatable way for continued monitoring. Once a suitable baseline measurement is established for all locations in the each structure, then the average threshold limit can be computed. An example projected value of the threshold limit is provided in Table below. It should be noted that the values in the table are presented as an example and are not intended to be applicable to actual locations.

Example Threshold Limits

Measurement ID	1	2	3	4
Measurement Type	Seismic Gap	Seismic Gap	Annulus Width	Annulus Width
Measurement Azimuth	180	305	220	240
Measurement Elevation	+5.5 ft	+21 ft	+9 ft	+9 ft
Relative-to Structure	CB	Personnel Hatch	CB	CB
Direction of deformation	Inward	Inward	Inward	Inward
Measurement taken from Inside or Outside of Annulus	Inside	Outside	Inside	Inside
Baseline Measurement Date and Report Reference	April 2016 [XX]	April 2016 [XX]	April 2016 [XX]	April 2016 [XX]
$d_{n,baseline}$, in.	1.5	1.97	51.00	52.00
$d_{n,design}$, in.	3.0	3.0	54.00	54.00
Baseline Measurement, in. $\lvert d_{n,baseline} - d_{n,design} \rvert$	1.50	1.03	3.00	2.00
$d_{n,FEA,baseline}$, in.	-0.34	-0.65	-1.01	-0.41
$d_{n,FEA,1.2}$, in.	-0.34	-0.69	-1.18	-0.48
$k_{n,thf}$	1.01	1.05	1.17	1.17
Local Threshold Limit, in. $\lvert d_{n,baseline} - d_{n,design} \rvert \times k_{n,thf}$	1.52	1.08	3.51	2.34
Average of Baseline Measurements			**1.88 in.**	
Threshold Limit (based on projected baseline values)			**2.11 in.**	

Summary

In summary, the process will classify affected structures into one of three categories: (1) structures with minimal amounts of deformation that do not affect the structural capacity as determined in the original design analysis; (2) structures with elevated levels of deformation that are shown to be acceptable using Finite Element Analysis (FEA) but still meeting the original design basis requirements when ASR effects are included; and (3) structures with significant deformation that are analyzed and shown to meet the requirements of the code of record using the methods described herein.

This approach is consistent with guidance in ACI 349.3R-1996 used to establish the inspection criteria for the Structures Monitoring Program. The ASR deformation categories do not necessarily correspond to the criteria used to characterize ASR cracking in structures that is discussed in LRA section B.2.1.31A. That is, a Stage 2 structure does not necessarily have ASR cracking that is classified as Tier 2. Structures will be monitored based on the most limiting parameter for monitoring from either the ASR Monitoring Program or the Building Deformation Monitoring Program. The building deformation monitoring ~~frequency for structures for each Stage are~~ ***frequency for structures for each Stage is*** summarized in Table 3.

Table 3 Structure Deformation Monitoring Requirements

Stage	Deformation Evaluation Stage	Monitoring Interval
1	Screening assessment	3 years
2	Analytical Evaluation	18 months
3	Detailed Evaluation	6 months

The monitoring frequencies in Table are based on guidelines developed for inspecting transportation structures with ASR degradation. The guidance recommends inspections from six months to 5 years depending on the age of the damage to the structure and the rate of change in degradation. The interval for recording monitoring elements for deformation for each structure can be increased to the interval in the next lower Stage (i.e., Stage 3 to Stage 2 and Stage 2 to Stage 1) if no change in measurements are observed for 3 years. Stage 1 structures that have shown no change in deformation for 10 years may increase the inspection interval to once every 5 years. Structures that show no evidence of building deformation will continue to be inspected with a frequency as established by the Structures Monitoring Program.

Components Impacted by Structural Deformation

With deformation, an aging effect of concern is component functionality and structural interferences. Condition walkdowns are performed with a focus on safety-related components such as pumps, valves, conduits, piping etc. The identification of items of interest is entered into the Seabrook Corrective Action Program (CAP) to be dispositioned for impact on plant structures. Specific features to look for include, but are not limited to, the following:

- Distorted flexible couplings
- Non-parallel pipe/conduit/HVAC joints
- Gaps, distortions, or tears in seals
- Crimped tubing
- Distorted support members/structural steel
- Distorted/bent anchor bolts
- Offset rod hangers
- Support members exceeding minimum clearance
- Cracked welds
- Support embedment plates – not flush with walls
- Misaligned pipe flanges
- Misaligned pipes in penetrations
- Roof membranes and weather seals degraded
- Electrical box, panel, or fitting distorted

Component specific features may indicate irreversible deformation of the affected component or irreversible plastic deformation of the structure such as rebar yielding or rebar slip. If these features are observed, then they will be documented in the corrective action process so that future monitoring walkdowns will observe the same features. Inspections of these features are in addition to the installed monitoring elements such as strain measurements and measurements of the relative deformation between structures. All of these measurements will be performed at the frequency described in Table 1.

The walkdowns will be performed in accordance with the Structures Monitoring Program and ASME Section XI, Subsection IWL Program documents. Seabrook will update the walkdown guidance documents as necessary to accommodate new Operating Experience (OE) identified during the walkdowns.

ELEMENT 4 - Detection of Aging Effects

As discussed in Element 3 baseline walkdowns to identify the potential effects caused by building deformation will be performed. The results of the baseline walkdowns will be used to determine the key assumptions in the structural analysis in addition to determining the monitoring frequencies for equipment impacted by building deformation. Subsequent monitoring will be performed as part of future ~~Structural~~ ***Structures*** Monitoring Program (SMP) walkdowns. The inspection frequencies identified by Table 1 will be applied in locations where symptoms of deformation are identified; otherwise, the inspection frequency will follow the requirements of the SMP. The SMP includes periodic visual inspection of structures and components for the detection of aging effects specific for that structure. The inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found.

ELEMENT 5 - Monitoring and Trending

Once the inspection frequencies are determined as described by Element 3, visual inspections will be used to monitor and trend future building deformation. Any new indications of building deformation will be placed in the Corrective Action Program, and evaluations will be performed to determine if inspection frequencies should be changed to ensure that future effects of degradation would be identified before loss of components' intended function.

ELEMENT 6 - Acceptance Criteria

A systematic approach to evaluation of structures and components impacted by ASR expansion and building deformation is utilized. A structural model is developed where ASR induced expansion is applied to the structure developing force, moments, and displacements that are attributed to the effects of ASR. The added load due to ASR is then combined with other CLB loads (deadweight, wind, hydrostatic, seismic, etc.). Resultant load combinations are then evaluated to validate compliance with structural design code requirements

Specific quantitative criteria to ensure component-intended functions will be maintained under all design conditions and is condition and location specific. Field observations of distorted/misaligned components and local structural deformation indicated by strain measurements or relative building movements are evaluated utilizing the existing acceptance criteria or design code specified for the design function of the component.
NextEra will determine appropriate criteria based on the walkdown results and the particular geometry and configuration in the area of interest. The criteria will include margin to trigger action prior to loss of intended function whether that action is an additional inspection or repair/replacement of the component.

ELEMENT 7 - Corrective Actions

Structural evaluations are performed to ensure impacted structures are in compliance with the Current Licensing Basis are documented in the Corrective Action Program. The NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 7 Corrective Actions. (Ref: LRA A.1.5 and B.1.3.)

ELEMENT 8 - Confirmation Process

The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 8 Confirmation Process.

ELEMENT 9 - Administrative Controls

The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 9 Administrative Controls.

ELEMENT 10 - Operating Experience

Building Deformation – Containment Enclosure Building (CEB)

In late 2014, a walkdown was performed to investigate a concern from the NRC that water, leaking from SB-V-9, was leaking into the Mechanical Penetration (Mech Pen) area though building seals. The walkdown documented that a Mechanical Penetration area seal was found torn. The damaged seal was a vertical seismic gap seal between the Containment Enclosure Building (CEB) and the Containment Building (CB). It was then stated that the condition of the seal and other local evidence indicated that the damage to the seal appeared to be caused by relative building movement and not seal degradation (i.e. shrinkage or material deterioration).

Following the discovery mentioned above, Engineering identified that the damage to the seal was caused by CEB outward radial deformation. Seabrook engaged an engineering firm to perform visual assessments of accessible areas surrounding the

CEB to determine the behavior of the CEB, whether the CEB movement is localized or widespread, and if other plant structures or components had been impacted. A Cause and Effect Diagram was prepared to understand the physical phenomena occurring with the CEB. Parametric studies using a linear finite element model of the CEB with boundary conditions modeling parameters appropriate for estimating structural deflections and deformed shapes were performed. The results were compared to in-situ field measurements taken between structures and at seismic isolation joints between various structures. The deformation patterns simulated by finite element analysis (FEA) were generally similar to field measurements. The results of the FEA showed that the deformation of the CEB was most likely due to Alkali-Silica Reaction (ASR) expansion in the concrete when combined with the expected creep and swelling of the concrete.

The root cause to the event was determined to be the internal expansion (strain) in the CEB concrete produced by ASR in the in-plane direction of the CEB shell and ASR expansion in the backfill concrete coincident with a unique building configuration. The Root Cause Evaluation identified that there are many different symptoms of building deformation. These include:

- Conduit, duct, or piping seismic connection deformation
- Gate or door misalignment
- Seismic gap seal degradation
- Seismic gap width variations
- Fire seal degradation

(Note: above list is not intended to be all inclusive)

As a result walkdowns were performed to identify the above symptoms that may have been missed during the ~~Structural~~ ***Structures*** Monitoring Program Walkdowns that were conducted prior to this discovery. The items identified were entered Seabrook's Corrective Action Program.

Building Deformation – RHR & FSB

Seabrook is currently evaluating observations of expansion resulting in building deformation in the Residual Heat Removal (RHR) Equipment Vault and the Fuel Storage Building (FSB). Because the evaluation of the RHR Equipment Vault and the FSB are ongoing and the observed deformation has not yet been conclusively attributed to ASR, the walkdown guidance has not been updated to reflect observations in these locations.

Plant Specific Operating Experience

AR 02044627 notes that the as-measured width of seismic isolation gaps is less than the nominal value of 3 inches specified on concrete drawings for isolation between structures. There are a total of 93 as-measured gaps less than 3 inches between the following abutting structures: Containment Building, Containment Enclosure Building, Mechanical Penetration Area, West Main Steam and Feed Water Pipe Chase, Electrical Penetration Area and Emergency Feed Water Pump House. Initial finite element analysis completed determined that the deformation is attributed to ASR expansion and creep. The compensatory measure implemented requires measuring seismic isolation gaps every six months.

AR 2114299 documents that a seismic isolation joint located on an expansion boot near ductwork in the Containment Enclosure Building is vertically misaligned by approximately 2". The boot appeared to be in good shape***; it was*** ~~and~~ not dry or cracking. The AR determined that the cause of the misalignment is building deformation of the Containment Enclosure Building. The engineering evaluation concluded that the displaced ducts resulted in some slipping of the expansion joint material relative to the clamp at the areas of highest relative movement and that there is reasonable assurance that the joint material would most likely slip rather than tear or elongate during a seismic event. The condition was found acceptable as is and no loss of intended function was identified.

AR 02107225 documents a deformed and misaligned flexible coupling on a conduit located in the West Pipe Chase area. Based on a field walkdown, the coupling was misaligned by 1.75" which is greater than the established 1.25" acceptable limit. The cause of the misalignment was building deformation. Therefore, engineering analysis was performed to ensure that the enclosed cable can continue to perform its safety function. Even though the cable could continue to perform its safety function, the flexible conduit was repaired to restore design margin.

AR 02129621 documents the seismic gap between Containment and the CEB horizontal cantilevered concrete shield block at Azimuth 230 elevation 22' is less the ~~the~~ minimum required seismic gap of .277 inches. The cause of the reduced gap was building deformation. An engineering analysis was performed to ensure that the structural remains operable while steps are taken to restore to design requirements.

Newly Identified Operating Experience (OE)

Seabrook will update the Aging Management Program for any new plant-specific or industry OE. This includes ongoing industry studies performed both nationally and internationally. Research data taken from these studies will be used to enhance the Building Deformation Monitoring Program, if applicable. In addition NextEra Seabrook has submitted a License Amendment Request to the Commission in accordance with 10CFR50.90 to incorporate a revised methodology related to ASR material properties and building deformation analysis for review and approval.

NextEra will incorporate changes related to this LAR submittal as necessary to maintain alignment of the aging management program to the current license basis.

EXCEPTIONS TO NUREG-1800

None

ENHANCEMENTS

Implement the Building Deformation (BD) Monitoring Program

The Seabrook Structural Monitoring Procedure EDS 36180 will be revised to include building deformation aging effects, inspection criteria, and acceptance criteria.

CONCLUSION

To manage the aging effects of building deformation due to ASR, swell, creep, and expansion, the existing Structures Monitoring Program and ASME Section XI, Subsection IWL Program, have been augmented by this plant specific Building Deformation Monitoring Program. This program will perform baseline inspections to determine the extent of deformation, input the inspection results into an analytical model, and use this model to determine the projected rate of future deformation, and set inspection frequencies both to ensure that the calculated deformation rate is valid, and the established monitoring frequencies ensure that intended functions for structures and components will be maintained.

Enclosure 4 to SBK-L-16181

LRA Appendix A - Final Safety Report Supplement Table A.3, License Renewal Commitment List Updated to Reflect Changes to Date

A.3 LICENSE RENEWAL COMMITMENT LIST

No.	PROGRAM or TOPIC	COMMITMENT	UFSAR LOCATION	SCHEDULE
1.	PWR Vessel Internals	Provide confirmation and acceptability of the implementation of MRP-227-A by addressing the plant-specific Applicant/Licensee Action Items outlined in section 4.2 of the NRC SER.	A.2.1.7	Complete
2.	Closed-Cycle Cooling Water	Enhance the program to include visual inspection for cracking, loss of material and fouling when the in-scope systems are opened for maintenance.	A.2.1.12	Prior to the period of extended operation.
3.	Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems	Enhance the program to monitor general corrosion on the crane and trolley structural components and the effects of wear on the rails in the rail system.	A.2.1.13	Prior to the period of extended operation.
4.	Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems	Enhance the program to list additional cranes for monitoring.	A.2.1.13	Prior to the period of extended operation.
5.	Compressed Air Monitoring	Enhance the program to include an annual air quality test requirement for the Diesel Generator compressed air sub system.	A.2.1.14	Prior to the period of extended operation.
6.	Fire Protection	Enhance the program to perform visual inspection of penetration seals by a fire protection qualified inspector.	A.2.1.15	Prior to the period of extended operation.
7.	Fire Protection	Enhance the program to add inspection requirements such as spalling, and loss of material caused by freeze-thaw, chemical attack, and reaction with aggregates by qualified inspector.	A.2.1.15	Prior to the period of extended operation.
8.	Fire Protection	Enhance the program to include the performance of visual inspection of fire-rated doors by a fire protection qualified inspector.	A.2.1.15	Prior to the period of extended operation.

9.	Fire Water System	Enhance the program to include NFPA 25 (2011 Edition) guidance for "where sprinklers have been in place for 50 years, they shall be replaced or representative samples from one or more sample areas shall be submitted to a recognized testing laboratory for field service testing".	A.2.1.16	Prior to the period of extended operation.
10.	Fire Water System	Enhance the program to include the performance of periodic flow testing of the fire water system in accordance with the guidance of NFPA 25 (2011 Edition).	A.2.1.16	Prior to the period of extended operation.
11.	Fire Water System	Enhance the program to include the performance of periodic visual or volumetric inspection of the internal surface of the fire protection system upon each entry to the system for routine or corrective maintenance to evaluate wall thickness and inner diameter of the fire protection piping ensuring that corrosion product buildup will not result in flow blockage due to fouling. Where surface irregularities are detected, follow-up volumetric examinations are performed. These inspections will be documented and trended to determine if a representative number of inspections have been performed prior to the period of extended operation. If a representative number of inspections have not been performed prior to the period of extended operation, focused inspections will be conducted. These inspections will commence during the ten year period prior to the period of extended operation and continue through the period of extended operation.	A.2.1.16	Within ten years prior to the period of extended operation.

12.	Aboveground Steel Tanks	Enhance the program to include 1) In-scope outdoor tanks, except fire water storage tanks, constructed on soil or concrete, 2) Indoor large volume storage tanks (greater than 100,000 gallons) designed to near-atmospheric internal pressures, sit on concrete or soil, and exposed internally to water, 3) Visual, surface, and volumetric examinations of the outside and inside surfaces for managing the aging effects of loss of material and cracking, 4) External visual examinations to monitor degradation of the protective paint or coating, and 5) Inspection of sealant and caulking for degradation by performing visual and tactile examination (manual manipulation) consisting of pressing on the sealant or caulking to detect a reduction in the resiliency and pliability.	A.2.1.17	Within 10 years prior to the period of extended operation.
13.	Fire Water System	Enhance the program to perform exterior inspection of the fire water storage tanks annually for signs of degradation and include an ultrasonic inspection and evaluation of the internal bottom surface of the two Fire Protection Water Storage Tanks per the guidance provided in NFPA 25 (2011 Edition).	A.2.1.16	Within ten years prior to the period of extended operation.
14.	Fuel Oil Chemistry	Enhance program to add requirements to 1) sample and analyze new fuel deliveries for biodiesel prior to offloading to the Auxiliary Boiler fuel oil storage tank and 2) periodically sample stored fuel in the Auxiliary Boiler fuel oil storage tank.	A.2.1.18	Prior to the period of extended operation.
15.	Fuel Oil Chemistry	Enhance the program to add requirements to check for the presence of water in the Auxiliary Boiler fuel oil storage tank at least once per quarter and to remove water as necessary.	A.2.1.18	Prior to the period of extended operation.
16.	Fuel Oil Chemistry	Enhance the program to require draining, cleaning and inspection of the diesel fire pump fuel oil day tanks on a frequency of at least once every ten years.	A.2.1.18	Prior to the period of extended operation.
17.	Fuel Oil Chemistry	Enhance the program to require ultrasonic thickness measurement of the tank bottom during the 10-year draining, cleaning and inspection of the Diesel Generator fuel oil storage tanks, Diesel Generator fuel oil day tanks, diesel fire pump fuel oil day tanks and auxiliary boiler fuel oil storage tank.	A.2.1.18	Prior to the period of extended operation.

18.	Reactor Vessel Surveillance	Enhance the program to specify that all pulled and tested capsules, unless discarded before August 31, 2000, are placed in storage.	A.2.1.19	Prior to the period of extended operation.
19.	Reactor Vessel Surveillance	Enhance the program to specify that if plant operations exceed the limitations or bounds defined by the Reactor Vessel Surveillance Program, such as operating at a lower cold leg temperature or higher fluence, the impact of plant operation changes on the extent of Reactor Vessel embrittlement will be evaluated and the NRC will be notified.	A.2.1.19	Prior to the period of extended operation.
20.	Reactor Vessel Surveillance	Enhance the program as necessary to ensure the appropriate withdrawal schedule for capsules remaining in the vessel such that one capsule will be withdrawn at an outage in which the capsule receives a neutron fluence that meets the schedule requirements of 10 CFR 50 Appendix H and ASTM E185-82 and that bounds the 60-year fluence, and the remaining capsule(s) will be removed from the vessel unless determined to provide meaningful metallurgical data.	A.2.1.19	Prior to the period of extended operation.
21.	Reactor Vessel Surveillance	Enhance the program to ensure that any capsule removed, without the intent to test it, is stored in a manner which maintains it in a condition which would permit its future use, including during the period of extended operation.	A.2.1.19	Prior to the period of extended operation.
22.	One-Time Inspection	Implement the One Time Inspection Program.	A.2.1.20	Within ten years prior to the period of extended operation.
23.	Selective Leaching of Materials	Implement the Selective Leaching of Materials Program. The program will include a one-time inspection of selected components where selective leaching has not been identified and periodic inspections of selected components where selective leaching has been identified.	A.2.1.21	Within five years prior to the period of extended operation.
24.	Buried Piping And Tanks Inspection	Implement the Buried Piping And Tanks Inspection Program.	A.2.1.22	Within ten years prior to the period of extended operation.

25.	One-Time Inspection of ASME Code Class 1 Small Bore-Piping	Implement the One-Time Inspection of ASME Code Class 1 Small Bore-Piping Program.	A.2.1.23	Within ten years prior to the period of extended operation.
26.	External Surfaces Monitoring	Enhance the program to specifically address the scope of the program, relevant degradation mechanisms and effects of interest, the refueling outage inspection frequency, the training requirements for inspectors and the required periodic reviews to determine program effectiveness.	A.2.1.24	Prior to the period of extended operation.
27.	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components	Implement the Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components Program.	A.2.1.25	Prior to the period of extended operation.
28.	Lubricating Oil Analysis	Enhance the program to add required equipment, lube oil analysis required, sampling frequency, and periodic oil changes.	A.2.1.26	Prior to the period of extended operation.
29.	Lubricating Oil Analysis	Enhance the program to sample the oil for the Reactor Coolant pump oil collection tanks.	A.2.1.26	Prior to the period of extended operation.
30.	Lubricating Oil Analysis	Enhance the program to require the performance of a one-time ultrasonic thickness measurement of the lower portion of the Reactor Coolant pump oil collection tanks prior to the period of extended operation.	A.2.1.26	Prior to the period of extended operation.
31.	ASME Section XI, Subsection IWL	Enhance procedure to include the definition of "Responsible Engineer".	A.2.1.28	Prior to the period of extended operation.
32.	Structures Monitoring Program	Enhance procedure to add the aging effects, additional locations, inspection frequency and ultrasonic test requirements.	A.2.1.31	Prior to the period of extended operation.
33.	Structures Monitoring Program	Enhance procedure to include inspection of opportunity when planning excavation work that would expose inaccessible concrete.	A.2.1.31	Prior to the period of extended operation.

34.	Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Implement the Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements program.	A.2.1.32	Prior to the period of extended operation.
35.	Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits	Implement the Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits program.	A.2.1.33	Prior to the period of extended operation.
36.	Inaccessible Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Implement the Inaccessible Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements program.	A.2.1.34	Prior to the period of extended operation.
37.	Metal Enclosed Bus	Implement the Metal Enclosed Bus program.	A.2.1.35	Prior to the period of extended operation.
38.	Fuse Holders	Implement the Fuse Holders program.	A.2.1.36	Prior to the period of extended operation.
39.	Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Implement the Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements program.	A.2.1.37	Prior to the period of extended operation.
40.	345 KV SF6 Bus	Implement the 345 KV SF6 Bus program.	A.2.2.1	Prior to the period of extended operation.
41.	Metal Fatigue of Reactor Coolant Pressure Boundary	Enhance the program to include additional transients beyond those defined in the Technical Specifications and UFSAR.	A.2.3.1	Prior to the period of extended operation.
42.	Metal Fatigue of Reactor Coolant Pressure Boundary	Enhance the program to implement a software program, to count transients to monitor cumulative usage on selected components.	A.2.3.1	Prior to the period of extended operation.

43.	Pressure –Temperature Limits, including Low Temperature Overpressure Protection Limits	Seabrook Station will submit updates to the P-T curves and LTOP limits to the NRC at the appropriate time to comply with 10 CFR 50 Appendix G.	A.2.4.1.4	The updated analyses will be submitted at the appropriate time to comply with 10 CFR 50 Appendix G, Fracture Toughness Requirements.

44.	Environmentally-Assisted Fatigue Analyses (TLAA)	NextEra Seabrook will perform a review of design basis ASME Class 1 component fatigue evaluations to determine whether the NUREG/CR-6260-based components that have been evaluated for the effects of the reactor coolant environment on fatigue usage are the limiting components for the Seabrook plant configuration. If more limiting components are identified, the most limiting component will be evaluated for the effects of the reactor coolant environment on fatigue usage. If the limiting location identified consists of nickel alloy, the environmentally-assisted fatigue calculation for nickel alloy will be performed using the rules of NUREG/CR-6909. (1) Consistent with the Metal Fatigue of Reactor Coolant Pressure Boundary Program Seabrook Station will update the fatigue usage calculations using refined fatigue analyses, if necessary, to determine acceptable CUFs (i.e., less than 1.0) when accounting for the effects of the reactor water environment. This includes applying the appropriate Fen factors to valid CUFs determined from an existing fatigue analysis valid for the period of extended operation or from an analysis using an NRC-approved version of the ASME code or NRC-approved alternative (e.g., NRC-approved code case). (2) If acceptable CUFs cannot be demonstrated for all the selected locations, then additional plant-specific locations will be evaluated. For the additional plant-specific locations, if CUF, including environmental effects is greater than 1.0, then Corrective Actions will be initiated, in accordance with the Metal Fatigue of Reactor Coolant Pressure Boundary Program, B.2.3.1. Corrective Actions will include inspection, repair, or replacement of the affected locations before exceeding a CUF of 1.0 or the effects of fatigue will be managed by an inspection program that has been reviewed and approved by the NRC (e.g., periodic non-destructive examination of the affected locations at inspection intervals to be determined by a method accepted by the NRC).	A.2.4.2.3	At least two years prior to the period of extended operation.

45.	*Alkali-Silica Reaction (ASR) Monitoring Program*	*NextEra will obtain additional cores in the vicinity of three extensometers and perform modulus testing. Using these test results, NextEra will determine the change in through-thickness expansion since installation of the extensometers and compare it to change determined from extensometer readings. Consistency between these results will provide additional corroboration of the methodology in MPR-4153.*	*A.2.1.31.A*	*At least 2 years prior to the period of extended operation.*
46.	Protective Coating Monitoring and Maintenance	Enhance the program by designating and qualifying an Inspector Coordinator and an Inspection Results Evaluator.	A.2.1.38	Prior to the period of extended operation.
47.	Protective Coating Monitoring and Maintenance	Enhance the program by including, "Instruments and Equipment needed for inspection may include, but not be limited to, flashlight, spotlights, marker pen, mirror, measuring tape, magnifier, binoculars, camera with or without wide angle lens, and self sealing polyethylene sample bags."	A.2.1.38	Prior to the period of extended operation.
48.	Protective Coating Monitoring and Maintenance	Enhance the program to include a review of the previous two monitoring reports.	A.2.1.38	Prior to the period of extended operation.
49.	Protective Coating Monitoring and Maintenance	Enhance the program to require that the inspection report is to be evaluated by the responsible evaluation personnel, who is to prepare a summary of findings and recommendations for future surveillance or repair.	A.2.1.38	Prior to the period of extended operation.
50.	ASME Section XI, Subsection IWE	Perform UT of the accessible areas of the containment liner plate in the vicinity of the moisture barrier for loss of material. Perform opportunistic UT of inaccessible areas.	A.2.1.27	Baseline inspections were completed during OR16. Repeat containment liner UT thickness examinations at intervals of no more than five (5) refueling outages.
51.	Number Not Used			
52.	ASME Section XI, Subsection IWL	Implement measures to maintain the exterior surface of the Containment Structure, from elevation -30 feet to +20 feet, in a dewatered state.	A.2.1.28	Complete

53.	Reactor Head Closure Studs	Replace the spare reactor head closure stud(s) manufactured from the bar that has a yield strength > 150 ksi with ones that do not exceed 150 ksi.	A.2.1.3	Prior to the period of extended operation.
54.	Steam Generator Tube Integrity	NextEra will address the potential for cracking of the primary to secondary pressure boundary due to PWSCC of tube-to-tubesheet welds using one of the following two options: 1) Perform a one-time inspection of a representative sample of tube-to-tubesheet welds in all steam generators to determine if PWSCC cracking is present and, if cracking is identified, resolve the condition through engineering evaluation justifying continued operation or repair the condition, as appropriate, and establish an ongoing monitoring program to perform routine tube-to-tubesheet weld inspections for the remaining life of the steam generators, or 2) Perform an analytical evaluation showing that the structural integrity of the steam generator tube-to-tubesheet interface is adequately maintaining the pressure boundary in the presence of tube-to-tubesheet weld cracking, or redefining the pressure boundary in which the tube-to-tubesheet weld is no longer included and, therefore, is not required for reactor coolant pressure boundary function. The redefinition of the reactor coolant pressure boundary must be approved by the NRC as part of a license amendment request.	A.2.1.10	Complete
55.	Steam Generator Tube Integrity	Seabrook will perform an inspection of each steam generator to assess the condition of the divider plate assembly.	A.2.1.10	Within five years prior to the period of extended operation.
56.	Closed-Cycle Cooling Water System	Revise the station program documents to reflect the EPRI Guideline operating ranges and Action Level values for hydrazine and sulfates.	A.2.1.12	Prior to the period of extended operation.
57.	Closed-Cycle Cooling Water System	Revise the station program documents to reflect the EPRI Guideline operating ranges and Action Level values for Diesel Generator Cooling Water Jacket pH.	A.2.1.12	Prior to the period of extended operation.
58.	Fuel Oil Chemistry	Update Technical Requirement Program 5.1, (Diesel Fuel Oil Testing Program) ASTM standards to ASTM D2709-96 and ASTM D4057-95 required by the GALL XI.M30 Rev 1.	A.2.1.18	Prior to the period of extended operation.

59.	Nickel Alloy Nozzles and Penetrations	The Nickel Alloy Aging Nozzles and Penetrations program will implement applicable Bulletins, Generic Letters, and staff accepted industry guidelines.	A.2.2.3	Prior to the period of extended operation.
60.	Buried Piping and Tanks Inspection	Implement the design change replacing the buried Auxiliary Boiler supply piping with a pipe-within-pipe configuration with leak detection capability.	A.2.1.22	Prior to the period of extended operation.
61.	Compressed Air Monitoring Program	Replace the flexible hoses associated with the Diesel Generator air compressors on a frequency of every 10 years.	A.2.1.14	Within ten years prior to the period of extended operation.
62.	Water Chemistry	Enhance the program to include a statement that sampling frequencies are increased when chemistry action levels are exceeded.	A.2.1.2	Prior to the period of extended operation.
63.	Flow Induced Erosion	Ensure that the quarterly CVCS Charging Pump testing is continued during the PEO. Additionally, add a precaution to the test procedure to state that an increase in the CVCS Charging Pump mini flow above the acceptance criteria may be indicative of erosion of the mini flow orifice as described in LER 50-275/94-023.	A.2.1.2	Prior to the period of extended operation.
64.	Buried Piping and Tanks Inspection	Soil analysis shall be performed prior to entering the period of extended operation to determine the corrosivity of the soil in the vicinity of non-cathodically protected steel pipe within the scope of this program. If the initial analysis shows the soil to be non-corrosive, this analysis will be re-performed every ten years thereafter.	A.2.1.22	Within ten years prior to the period of extended operation.
65.	Flux Thimble Tube	Implement measures to ensure that the movable incore detectors are not returned to service during the period of extended operation.	N/A	Prior to the period of extended operation. – In Progress

66.	*Alkali-Silica Reaction (ASR) Monitoring Program*	*NextEra will perform an integrated review of expansion trends at Seabrook Station by conducting a periodic assessment of ASR expansion behavior to confirm that the MPR/FSEL large-scale test programs remain applicable to plant structures. This review will include the following specific considerations:* • *Review of all cores removed to date for trends of any indications of mid-plane cracking.* • *Comparison of in-plane expansion to through-thickness expansion of all monitored points by plotting these data on a graph of CCI versus through-thickness expansion.* • *Comparison of in-plane expansions and through-thickness expansions recorded to date to the limits from the MPR/FSEL large-scale test programs and check of margin for future expansion. Also, the calculated volumetric expansion will be compared to the range observed in the beam test programs and margin for future expansion will be checked.*	*A.2.1.31.A*	*At least 5 years prior to the period of extended operation and every 10 years thereafter.*
67.	Structures Monitoring Program	Perform one shallow core bore in an area that was continuously wetted from borated water to be examined for concrete degradation and also expose rebar to detect any degradation such as loss of material. The removed core will also be subjected to petrographic examination for concrete degradation due to ASR per ASTM Standard Practice C856.	A.2.1.31	Complete
68.	Structures Monitoring Program	Perform sampling at the leak off collection points for chlorides, sulfates, pH and iron once every three months.	A.2.1.31	Complete
69.	Open-Cycle Cooling Water System	Replace the Diesel Generator Heat Exchanger Plastisol PVC lined Service Water piping with piping fabricated from AL6XN material.	A.2.1.11	Complete
70.	Closed-Cycle Cooling Water System	Inspect the piping downstream of CC-V-444 and CC-V-446 to determine whether the loss of material due to cavitation induced erosion has been eliminated or whether this remains an issue in the primary component cooling water system.	A.2.1.12	Within ten years prior to the period of extended operation.

71.	Alkali-Silica Reaction (ASR) Monitoring Program / Building Deformation Monitoring Program	NextEra has completed testing at the University of Texas Ferguson Structural Engineering Laboratory which demonstrates the parameters being monitored and acceptance criteria used are appropriate to manage the effects of ASR. NextEra will Implement the Alkali-Silica Reaction (ASR) Monitoring Program and Building Deformation Monitoring Program described in B.2.1.31A and B.2.1.31B of the License Renewal Application.	A.2.1.31A A.2.1.31B	Prior to the period of extended operation.
72.	Flow-Accelerated Corrosion	Enhance the program to include management of wall thinning caused by mechanisms other than FAC.	A.2.1.8	Prior to the period of extended operation.
73.	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components	Enhance the program to include performance of focused examinations to provide a representative sample of 20%, or a maximum of 25, of each identified material, environment, and aging effect combinations during each 10 year period in the period of extended operation.	A.2.1.25	Prior to the period of extended operation.
74.	Fire Water System	Enhance the program to perform sprinkler inspections annually per the guidance provided in NFPA 25 (2011 Edition). Inspection will ensure that sprinklers are free of corrosion, foreign materials, paint, and physical damage and installed in the proper orientation (e.g., upright, pendant, or sidewall). Any sprinkler that is painted, corroded, damaged, loaded, or in the improper orientation, and any glass bulb sprinkler where the bulb has emptied, will be evaluated for replacement.	A.2.1.16	Prior to the period of extended operation.

75.	Fire Water System	Enhance the program to a) conduct an inspection of piping and branch line conditions every 5 years by opening a flushing connection at the end of one main and by removing a sprinkler toward the end of one branch line for the purpose of inspecting for the presence of foreign organic and inorganic material per the guidance provided in NFPA 25 (2011 Edition) and b) If the presence of sufficient foreign organic or inorganic material to obstruct pipe or sprinklers is detected during pipe inspections, the material will be removed and its source is determined and corrected. In buildings having multiple wet pipe systems, every other system shall have an internal inspection of piping every 5 years as described in NFPA 25 (2011 Edition), Section 14.2.2.	A.2.1.16	Prior to the period of extended operation.
76.	Fire Water System	Enhance the Program to conduct the following activities annually per the guidance provided in NFPA 25 (2011 Edition). • main drain tests • deluge valve trip tests • fire water storage tank exterior surface inspections	A.2.1.16	Prior to the period of extended operation.
77.	Fire Water System	The Fire Water System Program will be enhanced to include the following requirements related to the main drain testing per the guidance provided in NFPA 25 (2011 Edition). • The requirement that if there is a 10 percent reduction in full flow pressure when compared to the original acceptance tests or previously performed tests, the cause of the reduction shall be identified and corrected if necessary. • Recording the time taken for the supply water pressure to return to the original static (nonflowing) pressure.	A.2.1.16	Prior to the period of extended operation.
78.	External Surfaces Monitoring	Enhance the program to include periodic inspections of in-scope insulated components for possible corrosion under insulation. A sample of outdoor component surfaces that are insulated and a sample of indoor insulated components exposed to condensation (due to the in-scope component being operated below the dew point), will be periodically inspected every 10 years during the period of extended operation.	A.2.1.24	Prior to the period of extended operation.

79.	Open-Cycle Cooling Water System	Enhance the program to include visual inspection of internal coatings/linings for loss of coating integrity.	A.2.1.11	Within 10 years prior to the period of extended operation.
80.	Fire Water System	Enhance the program to include visual inspection of internal coatings/linings for loss of coating integrity.	A.2.1.16	Within 10 years prior to the period of extended operation.
81.	Fuel Oil Chemistry	Enhance the program to include visual inspection of internal coatings/linings for loss of coating integrity.	A.2.1.18	Within 10 years prior to the period of extended operation.
82.	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components	Enhance the program to include visual inspection of internal coatings/linings for loss of coating integrity.	A.2.1.25	Within 10 years prior to the period of extended operation.
83.	Alkali-Silica Reaction Monitoring	Enhance the ASR AMP to install extensometers in all Tier 3 areas of two dimensional reinforced structures to monitor expansion due to alkali-silica reaction in the out-of-plane direction. Monitoring expansion in the out-of-plane direction will commence upon installation of the extensometers and continue on a six month frequency through the period of extended operation.	A.2.1.31A	~~December 31,2016~~. ***February 28, 2017***
84.	ASME Section XI, Subsection IWL	Evaluate the acceptability of inaccessible areas for structures within the scope of ASME Section XI, Subsection IWL Program.	A.2.1.28	Prior to the period of extended operation.
85.	Fire Water System	Enhance the program to perform additional tests and inspections on the Fire Water Storage Tanks as specified in Section 9.2.7 of NFPA 25 (2011 Edition) in the event that it is required by Section 9.2.6.4, which states "Steel tanks exhibiting signs of interior pitting, corrosion, or failure of coating shall be tested in accordance with 9.2.7."	A.2.1.16	Prior to the period of extended operation.

86.	Fire Water System	Enhance the program to include disassembly, inspection, and cleaning of the mainline strainers every 5 years.	A.2.1.16	Prior to the period of extended operation.
87.	Fire Water System	Increase the frequency of the Open Head Spray Nozzle Air Flow Test from every 3 years to every refueling outage to be consistent with LR-ISG-2012-02, AMP XI.M27, Table 4a.	A.2.1.16	Prior to the period of extended operation.
88.	Fire Water System	Enhance the program to include verification that a) the drain holes associated with the transformer deluge system are draining to ensure complete drainage of the system after each test, b) the deluge system drains and associated piping are configured to completely drain the piping, and c) normally-dry piping that could have been wetted by inadvertent system actuations or those that occur after a fire are restored to a dry state as part of the suppression system restoration.	A.2.1.16	Within five years prior to the period of extended operation.
89.	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components	Incorporate Coating Service Level III requirements into the RCP Motor Refurbishment Specification for the internal painting of the motor upper bearing coolers and motor air coolers. All four RCP motors will be refurbished and replaced using the Coating Service Level III requirements prior to entering the period of extended operation.	A.2.1.25	Prior to the period of extended operation.
90.	PWR Vessel Internals	Implement the PWR Vessel Internals Program. The program will be implemented in accordance with MRP-227-A (Pressurized Water Reactor Internals Inspection and Evaluation Guidelines) and NEI 03-08 (Guideline for the Management of Materials Issues).	A.2.1.7	Prior to the period of extended operation

91	Building Deformation Monitoring	Implement the Building Deformation Monitoring Program Enhance the Structures Monitoring Program to require structural evaluations be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained. Evaluations of structures will validate structural performance against the design basis, and may use results from the large-scale test programs, as appropriate. Evaluations for structural deformation will also consider the impact to functionality of affected systems and components (e.g., conduit expansion joints). NextEra will evaluate the specific circumstances against the design basis of the affected system or component. Enhance the Building Deformation AMP to include additional parameters to be monitored based on the results of the CEB Root Cause, Structural Evaluation and walk downs. Additional parameters monitored will include: alignment of ducting, conduit, and piping; seal integrity; laser target measurements; key seismic gap measurements; and additional instrumentation. ***Develop a design standard to implement Aging Management Program B.2.1.31B Building Deformation, Program Element 3 - Parameters Monitored/Inspected. The design standard will clarify the deformation evaluation process and provide an auditable format to assess it. The design standard will include steps for each of the three evaluation stages that include parameters monitored, basis for why the parameter is monitored, and conditions that prompts action for the subsequent step.***	A.2.1.31B	March 15, 2020