Union of Concerned Scientists

# STATEMENT ON CONCRETE DEGRADATION AT SEABROOK NUCLEAR STATION

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Thank you for the opportunity to address this meeting.

I want to start by noting that the Union of Concerned Scientists (UCS) does not take a position for or against nuclear power. Instead our goal is to increase the safety of nuclear plants, since we believe that as long as nuclear reactors continue to operate, the Nuclear Regulatory Commission (NRC) and nuclear industry should have a very high safety bar, given the potential risks to the public.

Especially in a case like Seabrook Nuclear Station, which is known to show deterioration of its concrete, we believe the burden of proof is on the NRC to fully understand and address the issues. However, many unanswered questions remain, and based on current information we are not assured that these issues are being adequately addressed.

Let me also note that I am not an expert on concrete or the details of testing that one must do to understand the potential effects of concrete degradation. For that reason, UCS has hired a well-known expert on concrete—Prof. Paul Brown of Penn State University—to help us identify the key issues, review NRC and NextEra documents, and comment on them. Paul is unfortunately not able to join the meeting today.

Here is the current situation at Seabrook:

- Concrete degradation by alkali silica reaction (ASR) has been discovered at 131 locations in multiple structures at Seabrook.[1] ASR is a chemical reaction occurring in the concrete used at Seabrook when exposed to water. This reaction causes expansion and cracking of the concrete, which over time can weaken the concrete and in some situations result in steel reinforcing rods embedded in the concrete to corrode and weaken.

- Chemical studies of the concrete at Seabrook show that the ASR reaction and expansion will continue into the future, so that additional ASR damage could be significant.[2] Understanding this continuing ASR damage is important since the license extension that NextEra is requesting would allow Seabrook to operate for another 37 years (until 2050). This is longer than the roughly 30 years the concrete has currently been in place (construction was completed in 1986).

- Seabrook is the first nuclear plant in the U.S. fleet in which ASR concrete degradation has been discovered. As a result, there is no existing technical or regulatory basis for this adverse condition.

- Today the NRC and NextEra are still assessing the situation at Seabrook to understand the current extent and potential consequences of the ASR problem. There have been no meaningful analyses to determine how fast the concrete will degrade.

- There is no generally accepted technology to mitigate the effects of ASR within an existing concrete structure.[3] As a result, the best one can do is to work to develop reliable methods of ongoing monitoring to understand the evolution of the structural damage over time.

Our assessment is that fundamental issues continue to plague the testing and inspection process at Seabrook. These severely limit the ability to understand the current extent of the concrete degradation, to develop adequate monitoring of the deterioration over the next several decades, and to devise processes for countering the deterioration and maintaining structural integrity at Seabrook.

In November, UCS sent a letter to the NRC discussing some of our main concerns about the situation at Seabrook.[4] In its response to our letter,[5] the NRC agreed with many of our points, but did not give us confidence that it was adequately addressing the concerns we raised. These concerns include:

*Continuing Use of an Unjustified Measure of ASR*

NextEra's assessment of ASR damage relies primarily on monitoring the width of cracks observed in the surface of the concrete.[6] This is problematic for two reasons.

First, NextEra uses a "combined crack index" (CCI) that considers crack widths as the parameter characterizing ASR damage, but there is not a well-established basis for relying on crack widths as a reliable measure of the extent of ASR and damage in highly reinforced concrete.[7]

This is because steel reinforcement bars in the concrete may reduce the growth in the width of cracks in the concrete, but will not limit the progression of the ASR itself. The ASR expansion may therefore create dense networks of microcracks in the bulk of the concrete. This deterioration can therefore weaken the concrete but may not show up as large cracks on the concrete surface. As a result, an index that instead reflects the total lengths of cracks is expected to be a more reliable indicator of the extent of ASR.

In addition, a crack-width index has not been shown to be predictive of when a structure has been compromised to the point that the structure becomes vulnerable to failure.[8]

Second, observing surface damage of a concrete structure is not a reliable way to understand the extent of damage that has occurred within the body of the concrete. This is especially true in concrete with internal reinforcing bars, which constrain crack widths but do not limit the progression of the ASR. As a result, there is currently no reliable way of assessing the extent of ASR and the resulting damage to the concrete without extracting and testing core sample from the affected concrete structures. NextEra has made very limited use of core samples from the Seabrook structures.

*Inadequate Assessment of Corrosion of Embedded Rebar*

Much of the strength of concrete structures comes from steel reinforcing bars, or rebars, embedded in the concrete. Corrosion of rebar from water that that seeps into cracks in the concrete can weaken the structure.

In its response to our November letter, the NRC confirms that "no detailed or exhaustive analysis was conducted to assess the impact of ground water infiltration on rebar." It argues that such an analysis is unnecessary since "the NRC has reasonable assurance that corrosion of the rebar is not occurring because generally, the alkali environment within the concrete inhibits corrosion and no surface indications of corrosion have been observed."[9]

This response misses a key point we raised in our letter. If the water that has infiltrated the concrete to cause ASR contains chloride and/or sulfate, those chemicals can lead to "depassivation," meaning that they can break down the usual protective alkali layers around embedded steel. That can result in corrosion of the embedded steel structures.

This is a concern since studies of the ground water at Seabrook reported in 2010 indicate that both chloride (19 to 3900 ppm) and sulfate (10 to 100 ppm) are present.[10] While some questions have been raised about these results, this remains an important unresolved issue. Even low-level concentrations of chloride (100 ppm or less) can lead to the corrosion of embedded steel.

The NRC's argument about the alkali layers is therefore not adequate. Assessing the chemistry of the ground water at Seabrook and what corrosion of steel has occurred to date is crucial for understanding the current status and potential future degradation of concrete structures at Seabrook.

Despite that, the NRC writes that "NextEra does not have a detailed ground water chemistry analysis program specific to the ASR monitoring program."[11] Until this is done, the NRC cannot say with any confidence what the risk to the rebar is.

*Problems with Applying Results of "Replica Testing" to Seabrook*

Instead of testing core samples taken from actual concrete structures at Seabrook, NextEra is planning to rely instead on "replica tests" being conducted at the University of Texas. These tests use concrete samples that are supposed to closely resemble the specific concrete used at Seabrook, with the goal of providing "sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures."[12] The NRC appears to be satisfied with this approach.

However, based on what he has learned about the University of Texas study, Dr. Brown has identified significant problems that limit its application to the Seabrook situation.

A major limitation is that the specific concrete materials originally used in the Seabrook concrete are no longer accessible from the quarry, so instead materials from another source are being used for the tests in Texas. Yet the behavior of the concrete depends on the specific chemical composition of the materials in it. The NRC therefore cannot assess how relevant the tests are to the situation at Seabrook until an expert (an "aggregate petrographer") compares the materials in the concrete in Seabrook and that being used in the Texas tests. To our knowledge, such testing has not been done.

Moreover, the publicly available information does not provide, for example, information on the methods of aggregate grading and sizing, on strength characteristics of the model concrete and the original concrete, and on the curing conditions of the model concrete compared to that of the original concrete—all of which are important to assess the applicability of the Texas results to Seabrook. The NRC inspectors need to understand all of these issues in detail before they can assess the relevance of the Texas study to the specific situation at Seabrook.

Understanding these issues is important enough that tests must also be carried out on the actual in-place concrete at Seabrook.[13]

Indeed, a better way to do these studies may be to take advantage of the fact that there are inactive buildings constructed for a second reactor at Seabrook that was never completed. These buildings used the same concrete as the structures of the operating reactor, and could be extensively tested and instrumented to evaluate the effects of ASR without the need of "replica" studies. Such tests are likely to provide more reliable results than the Texas study for evaluating ASR damage at Seabrook.

*The Importance of Weakened Concrete in Layered Construction*

NextEra argues that because of the steel rebars embedded in the concrete, a reduction due to ASR in the strength of the concrete surrounding the rebars is not important in understanding the mechanical properties of the overall structure. However, that is not true for layered structures like those at Seabrook.

Many of Seabrook's structures consist of planar layers of rebars surrounded by concrete, with these layers stacked on top of each other without the rebars running in the third direction to tie the layers together. As a result, it is the concrete between the layers that tie them together. Therefore, the strength of the overall structure will depend on the strength of the concrete that binds the layers together. Weakening of the concrete will therefore weaken the structure.

The Texas studies will attempt to look at this issue, but as noted above, the applicability of those tests to Seabrook must be established. Examining this issue in existing structures at Seabrook is likely to provide better information.

**Conclusion and Recommendations**

As noted, we do not have confidence that NextEra and the NRC are adequately addressing our concerns. As a result, we will continue to press for further action on these and other issues.

As part of this, we have the following recommendations:

- The NRC should make additional documents and information available to the public to allow a better evaluation of the inspections and tests being conducted at Seabrook, and their results.

- Given the importance of developing reliable monitoring methods for assessing the spread of ASR and its effects on structural properties of the concrete at Seabrook, NextEra must justify its use of surface monitoring of a crack index as an appropriate and reliable approach, or develop an alternate monitoring method with such justification.

- NextEra must conduct a detailed ground water chemistry analysis program specific to the ASR monitoring program at Seabrook. The data and results of that analysis should be made public.

- Given concerns about depassivation and rebar corrosion, Next Energy must conduct a detailed analysis to assess the impact of ground water infiltration on rebar throughout the Seabrook structures.

- NextEra should make more extensive use of core samples taken from structures at Seabrook and should use the inactive buildings at Seabrook for testing and monitoring of ASR effects, to reduce reliance on, if not eliminate the need for, replica testing.

- The results of the University of Texas replica testing must be made public and be subjected to independent review to confirm the findings and their applicability to Seabrook.

UCS is of course ready and willing to work the NRC and provide what help we can.

**Notes:**

[1] NextEra Energy, ASR Project Corrective Action Plan, April 2013, p. 11, http://pbadupws.nrc.gov/docs/ML1315/ML13151A328.pdf

[2] NRC Inspection Summary, December 3, 2012, http://pbadupws.nrc.gov/docs/ML1233/ML12338A283.pdf

[3] The NRC has responded that it agrees with this statement; see NRC Response to UCS, December 6, 2013, http://pbadupws.nrc.gov/docs/ML1334/ML13340A405.pdf

[4] UCS Letter to NRC, November 4, 2013, http://www.ucsusa.org/assets/documents/nuclear_power/Seabrook-Concrete-Commissioner-letter.pdf and UCS/C-10 background document, November 4, 2013, http://www.ucsusa.org/assets/documents/nuclear_power/Seabrook-concrete-damage-report-2013.pdf

[5] NRC Response to UCS.

[6] NextEra Corrective Action Plan, p. 14, 19. NextEra states: "This makes crack mapping and indexing of the concrete surface an appropriate and reliable diagnostic tool for monitoring the progression of ASR. …The approach being applied to Seabrook is a combined crack index (CCI) that averages the crack indexes in the x and y in-plane directions." (p. 14) and "Monitoring the progression of ASR can be effectively accomplished by detailed visual inspections and trending of the observable surface of the structures. Crack mapping and expansion monitoring provides the best correlation to the progression of ASR in the structure." (p. 19).

[7] The NRC has responded that it agrees with this statement; see "NRC Response to UCS."

[8] The NRC has responded that it agrees with this statement; see "NRC Response to UCS."

[9] NRC Response to UCS.

[10] NextEra, Response to Request for Additional Information, December 17, 2010, p. 32, http://pbadupws.nrc.gov/docs/ML1035/ML103540534.pdf

[11] NRC Response to UCS.

[12] NRC Inspection Report, August 9, 2013, p. 5, http://pbadupws.nrc.gov/docs/ML1322/ML13221A172.pdf

[13] The NRC has responded that it agrees with this statement; see "NRC Response to UCS."