CONFIDENTIAL INFORMATION SUBMITTED UNDER 10 C.F.R. § 2.390



UNITED STATES OF AMERICA NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of

Docket No. 50-443-LA-2

NEXTERA ENERGY SEABROOK, LLC

(Seabrook Station, Unit 1)

ASLBP No. 17-953-02-LA-BD01

Hearing Exhibit

Exhibit Number:

Exhibit Title:

September 17, 2020

UNITED STATES OF AMERICA NUCLEAR REGULATORY COMMISSION BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

)

In the Matter of
NextEra Energy Seabrook, LLC
(Seabrook Station, Unit 1)

Docket No. 50-443

REBUTTAL SUPPLEMENTAL TESTIMONY OF VICTOR E. SAOUMA, PH.D REGARDING LICENSE CONDITIONS IN LBP-20-09

- The purpose of this Rebuttal Supplemental Testimony is to reply to statements in the Affidavit of Angela Buford, Bryce Lehman, Jacob Philip, and George Thomas in Response to C-10's Motion for Partial Reconsideration and to Reopen the Record (Sept. 10, 2020) ("Staff Aff.") regarding my supplemental testimony dated August 28, 2020, Supplemental Testimony of Victor E. Saouma, Ph.D Regarding License Conditions in LBP-20-09 ("Saouma Supp. Test."). This Rebuttal Testimony also responds to several statements by NextEra Energy Seabrook, LLC ("NextEra") in NextEra's Answer Opposing C-10's Motion for Leave and Motion for Partial Reconsideration of LBP-20-9 (Sept. 10, 2020) ("NextEra Answer").
- 2. At the outset, I would like to address the issue of expertise. NextEra makes much of the Atomic Safety and Licensing Board's (ASLB's) conclusion that I am not an expert on U.S. Nuclear Regulatory Commission (NRC) regulations. NextEra Answer at 7 (citing LBP-20-0, slip op. at 50). Therefore, NextEra asserts that I am not qualified to comment on what measures are necessary for a "reasonable assurance" finding. Id. I have never claimed to be an expert on NRC regulations, nor does my Supplemental Testimony address the reasonable assurance standard. My Supplemental Testimony sets forth my expert opinion regarding reasonably accurate and reliable measures for monitoring and assessing the progress of alkali-silica reaction (ASR) in concrete, a topic on which I am highly qualified by training and experience. See LBP-20-09, slip op. at 50 (finding that based on my status as a "preeminent researcher in the science of ASR degradation in concrete" and my technical experience on "numerous projects" related to ASR, I am "qualified to testify regarding sound engineering practices in the management of ASR.") I would also note that NextEra did not provide any expert technical response to my proposed changes to the ASLB's license conditions, but relied instead on the comments of its attorneys, who have no technical expertise on ASR.
- 3. I also want to point out that none of the four members of the Staff who sponsored the Staff Affidavit professes to have expertise with respect to ASR monitoring, analysis or management. Rather, they claim to have general expertise with the NRC's regulatory processes and "an extensive understanding of the Seabrook LAR [license amendment request] through multiple inspections, audits requests for additional information, and public meetings." Staff Aff., A.6 at 5. Thus, it is not surprising that,

as discussed below, these Staff members misconstrue some technical issues related to my proposed changes to the license conditions, and have failed to show that my proposed changes are unnecessary to ensure the timely and reliable detection of ASR progression.

License Condition (c)

- 4. In response to License Condition (c), I urged the ASLB to add language to the "Check 3" mandatory license condition, which directs NextEra to check the reliability of the extensometer threshold. I proposed to add language that would (a) require the use of error bars and (b) provide for independent review by the NRC Staff. Saouma Supp. Test., ¶ 5.
- 5. As stated by the NRC Staff, the purpose of License Condition (c) is to "ensure the prompt detection of any observation that would challenge" the threshold of a combined crack index of (CCI) of 1.0 mm/m (0.1%) for installation of an extensometer. Staff. Aff., A.7 at 6. As the Staff observes, "[t]he Board determined that this monitoring would satisfy the reasonable assurance standard despite the differences in aggregate chemical composition and structure between the LSTP [large-scale test program] and Seabrook." *Id.* But the Staff asserts that the purpose of License Condition (c) would not be served by "adding error bars to this monitoring process." *Id.* at 7. And in any event, the Staff asserts that a requirement to use error bars would be inconsistent with the ASLB's finding that "the extensometers in use at Seabrook provide accurate and reliable measurements for monitoring through-thickness expansion." *Id.* (citing LBP-20-09, slip op. at 65).
- 6. The Staff fundamentally misconstrues both my testimony and LBP-20-09. In my testimony, I have not questioned NextEra's testimony regarding the general technical accuracy and reliability of extensometers to measure cracking. Instead, my concern relates to the accuracy and reliability of NextEra's *interpretation of extensometer readings* to make the crucially important determination of the degree of out-of-plane expansion in Seabrook concrete.¹
- 7. As recognized by the ASLB, I identified a "lack of concrete representativeness" between the LSTP specimens and Seabrook concrete that "may compromise the reliability of the extensometer threshold for the extensometer installation of 1.0 mm/m (0.1%) (the extensometer threshold)." LBP-20-09, slip op. at 91. The ASLB agreed, expressing concern "with the specific question whether the LSTP specimens are sufficiently representative of Seabrook concrete such that the crack widths, cracking patterns, and expansion rates observed in the test specimens justify the conclusion that significant through-thickness expansion will not occur in Seabrook seismic Category I structures as long as the CCI remains below the 1.0 mm/m (0.1%) threshold." *Id.*, slip op. at 93. In addition, the ASLB specifically stated that "[g]eneral

¹ I would note that the Staff incorrectly characterizes NextEra's testimony on the general reliability of extensioneters as a conclusion by the ASLB. Staff Aff., A.7 and 19 (citing LBP-20-09 at 65). The conclusion cited by the Staff, that extensioneters are "accurate and reliable," is a statement by NextEra, not the ASLB.

statements concerning the widespread acceptance of CCI are of little help" in resolving that issue. *Id.* Finally, even with the Check 3 license condition, the ASLB expressed its concern that "because the LSTP data was not sufficiently representative of Seabrook concrete, through-thickness cracking approaching the expansion limit may occur even though the extensometer threshold has not been reached." *Id.*, slip op. at 94. In addition, the ASLB noted that NextEra's own experts had "recognized that '[d]ata from Seabrook Station may exhibit further variability from differences in configuration (e.g., wall thickness) and confinement (e.g., from deadweight). LBP-20-09, slip op. at 95 (citing Ex. INT019, Report MPR-4273 at B-5).

- 8. Thus, contrary to the NRC Staff's suggestion, my purpose in proposing the use of error bars has nothing to do with the accuracy or reliability of extensometer equipment *per se*, and everything to do with accounting for the inherent uncertainties in NextEra's methodology for interpreting extensometer readings.
- 9. The Staff's argument that error bars are unnecessary is also undermined by ACI 318-71 (Ex. NRC049) and the EPRI Report (Ex. NER017). NextEra relies In ACI 318-71 for its use of an empirical heuristic approximate equation to determine the elastic modulus (Ec) from the compressive strength. This equation is also referred to at page 160 of LBP-20-09). The approximate nature of the equation is acknowledged in ACI 318-71 Sect. 8.3.1: "For normal weight concrete, Ec may be considered as 57,000 √f'c". (emphasis added). Importantly, ACI 318-71 does not say that 57,000 √f'c *is* the value of Ec. The uncertainty of this equation is also discussed in INT028, my Rebuttal Testimony at pages 36 and 37 (Proprietary). As shown by Figure 19 in my Rebuttal Testimony, the data scatter generated by application of the equation, with a spread of 80% to 120% between lower and upper values, justifies the use of error bars. Figure 19 is reproduced below:



INT028, Figure 19, Comparison between ACI empirical equation and exact value for E [PROPRIETARY INFORMATION]

10. NextEra also references the EPRI Report as the basis for the correlation method. Ex. NER001 at 118. Consistent with my recommended approach, the EPRI Report uses error bars for *all* of its figures. Of particular relevance are Figures 4-1(a) and 4-14, which relate to the impact of ASR on the elastic modulus:



Fig. 4-1(a) (Impact of ASR expansion on Elastic Modulus for unconfined concrete as reported in the literature)



Fig.4-14 (Change in Elastic Modulus with time)

11. Not only are error bars included in both these figures, but it is notable that the confined and unconfined (CON-SR and UNC-SR respectively) slow reacting concrete has the largest error bars and the smallest reduction. This is significant because

Seabrook's concrete contains slow-reaction aggregate, as indicated by NextEra during the hearing. Tr.402 (Bayrak).

- 12. In my professional opinion, therefore, the addition of a requirement for error bars is highly appropriate and necessary for any reasonably accurate or verifiable interpretation of the data.
- 13. The NRC Staff is incorrect in stating that I seek to apply the error bars in relation to the effect of aggregate chemical composition and structure on the correlation between reduced elastic modulus and past expansion. Staff Aff., A.7 at 6. As discussed above, the error bars should be applied to the methodology used by NextEra to interpret the extensometer results.
- 14. The NRC Staff also objects to my proposal that the Staff should independently review NextEra's use of error bars, on the ground that it is against NRC policy for license conditions to require reliance on NRC Staff actions. Staff Aff., A.7 at 7 and n. 21 (citing NRC Office Instruction LIC-101, "License Amendment Review Procedures" (July 31, 2020) (ML19248C539) ("LIC-101")). If the Staff is correct that Staff action should not be included in license conditions as a requirement, then omitting such a requirement would provide all the more reason for imposing a requirement of error bars, so that the Staff will have a clear indication of significant uncertainties during its regular enforcement reviews.

License Condition (d)

- 15. License Condition (d) requires the development of a monitoring program contingent on the results of future stress analyses. LBP-20-09, slip op. at 128. In my Supplemental Testimony, I urged the ASLB to add two conditions on the monitoring program. First, it should include the use of properly placed and attuned acoustic sensors to detect rebar fracture. Second, readings should be taken no less than every six months after commencement of the program. Saouma Supp. Test. ¶ 7.
- 16. The NRC Staff argues that acoustic sensors "are not necessary because "NextEra already conducts additional examination and analysis if code acceptance criteria are not met or if cracking index (CI) or CCI values exceed 2.0 mm/m (0.2%)." Staff Aff., A.8 at 8. According to the Staff, this value "is conservative with the yielding of rebar, which is expected to occur at a strain of approximately 2.1 mm/m (0.21%), based on the specified rebar minimum yield strength (60 ksi) divided by the elastic modulus of rebar (29000 ksi)." *Id.*
- 17. I do not agree that the value of 2.0 mm/m (0.2%) is "conservative" in relation to the yield strain of 2.1 mm/m (0.21%). The difference, *i.e.*, the safety margin, is only 5%. This is an unacceptably small margin under almost any circumstances, and even more unacceptable in light of (a) NextEra's testimony that 'the expansion potential is rather high" (LBP-20-09, slip op. at 127) and (b) the fact that there is no guidance for this type of monitoring. Saouma Supp. Test., ¶ 7. The addition of acoustic monitors is, in my expert opinion, essential to reduce the level of uncertainty to an acceptable level.

License Condition (e)

18. The ASLB imposed the following requirements in License Condition (e):

If the ASR expansion rate in any area of a Seabrook seismic Category I structure significantly exceeds 0.2 mm/m (0.02%) through-thickness expansion per year, NextEra's Management will perform an engineering evaluation focused on the continued suitability of the six-month monitoring interval for Tier 3 areas. If the engineering evaluation concludes that more frequent monitoring is necessary, it shall be implemented under the SMP.

LBP-20-09, slip op. at 140. In my Supplemental Testimony, I urged the ASLB to remove the word "significantly" and instead provide that if the expansion rate in any area exceeds 0.2 mm/m (0.02%), NextEra should perform an engineering evaluation. Saouma Supp. Test., ¶ 16.

- 19. The Staff agrees that the word "significantly" should be removed, because it "is not quantitatively defined and, thus, its inclusion in this condition would make it unclear under exactly what conditions NextEra would be required to perform an engineering evaluation." Staff Aff., A.9 at 9. I agree.

License Condition (f)

- 21. License Condition (f), requiring that each core extracted from Seabrook Unit 1 "will be subjected to a petrographic analysis to detect internal microcracking and delamination." LBP-20-09, slip op. at 185. Given the wide potential for interpretations of the term "petrographic," I urged the ASLB to add language requiring that petrographic methods should be capable of detecting microcracks as small as 10 µm. Saouma Supp. Test., ¶ 20.
- 22. According to the Staff, it is not necessary to detect microcracks as small as $10 \ \mu m$ in order to identify "microcracking that could lead to delamination." Staff Aff., A.10 at 11. The Staff also states that "delamination cracks are significantly wider than 10 μm and microcracks as small as 10 μm have no significance to structural capacity or response." *Id.* at 12. But the Staff misunderstands both my testimony and LBP-20-09.

- 23. First, the Staff misinterprets my testimony on the phenomenon on microcracking and how it relates to delamination. I did not testify that microcracks initially cause delamination. As I testified, microcracks may coalesce into macrocracks that cause delamination. LBP-20-09, slip op. at 173. I also testified that it is essential to use petrography to detect microcracks because a microcrack is "too small to be detected with the naked eye." *Id.*, slip op. at 174. And I identified petrography as a way to identify microcracking "with its potential for delamination beneath the surface." *Id.*, slip op. at 176.
- 24. The Staff also fails to recognize that the ASLB accepted my analysis, noting that "[m]icrocracks reduce the mechanical and material properties of ASR-affected concrete (compressive strength, elastic modulus, tensile strength, shear strength, and flexural strength) and may reduce its structural capacity." LBP=20-09, slip op. at 170 (citing Ex. NRC-001-R, NRC Staff Testimony at 7; tr. at 573-74 (Saouma)). The ASLB also found that NextEra had not properly accounted for "the possibility of delamination" (LBP-20-09, slip op. at 183-84) and that "NextEra does not have an adequate screening procedure to detect internal cracking and delamination in Seabrook's concrete." *Id.* at 184. And the ASLB further concluded that "petrographic analysis of each extracted core would gauge the degree of internal microcracking (possibly resulting in macrocracking) that could lead to catastrophic delamination." *Id.*, slip op. at 185.
- 25. Thus, there is no question that the ASLB intended for the petrographic analyses in License Condition (d) to detect microcracking. The only question is whether some further specification is needed in order to ensure that the resolution of the petrographic inspection is fine enough to detect microcracks.
- 26. As I testified, the term "petrographic" is subject to a range of interpretations. Saouma Supp. Test., ¶ 19. Thus, in order to fulfill the NRC Staff's policy that license conditions should be "worded such that the meaning is clear and not open to different interpretations" (LIC-101, App. B at 22), more guidance is needed regarding the quality and capability of petrographic studies to be performed by NextEra. I proposed a clear and quantitative detection capability of cracks as small as 10 µm. Contrary to NextEra's assertion (Answer at 7 n. 30), this is not a "random" number, a measurement that should be detectable with run-of-the-mill binocular microscopy. This is my expert opinion, and is consistent with Ex. NER075, the Swiss Dam Report.
- 27. As the NRC Staff suggests, another guide for a reasonably comprehensive and accurate petrographic analysis is provided by the industry standard ASTM C856, Standard Practice for Petrographic Examination of Hardened Concrete. Staff Aff., A.10 at 11-12. In my expert opinion, a reference to ASTMC856 as the governing guidance for NextEra's petrographic analyses would be an adequate substitute for specification of a quantitative detection capability of cracks as small as 10 µm.

This concludes my Rebuttal Supplemental Testimony.