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10CFR50.90

November 30, 2021

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

Calvert Cliffs Nuclear Power Plant, Units 1 and 2
Renewed Facility Operating License Nos. DPR-53 and DPR-69
Docket Nos. 50-317 and 50-318

Subject: Supplement to Response to Request for Additional Information Regarding the Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request

References:

1. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, “Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request,” dated June 14, 2021 (ADAMS Accession No. ML21165A406)

2. Letter from Michael Marshall, U.S. Nuclear Regulatory Commission to David P. Rhoades, Exelon Generation Company, LLC, “Calvert Cliffs Nuclear Power Plant, Units 1 and 2 – Audit Plan in Support of Review of License Amendment Request Regarding Change Spent Fuel Pool Cooling Design Basis (EPID L-2021-LLA-0112),” dated July 20,2021 (ADAMS Accession No. ML21200A074)

3. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, " Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request Supplement,” dated August 13, 2021 (ADAMS Accession No. ML21225A353)

4. Email from Andrea Mayer, U.S. Nuclear Regulatory Commission, to Francis J Mascitelli, Exelon Generation Company, LLC, " Request for Additional Information: Calvert Cliffs 1 & 2 LAR to Revise Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Basis (L-2021-LLA-0112)," dated October 5, 2021 (ADAMS Accession No. ML21287A093)

5. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information Regarding the Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request,” dated October 25, 2021 (ADAMS Accession No. ML21298A043)

6. Email from Andrea Mayer, U.S. Nuclear Regulatory Commission, to Francis J. Mascitelli, Exelon Generation Company, LLC, "Re: Calvert Cliffs SFPC-SDC LAR RAI Response," dated November 2, 2021

7. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Supplement to Response to Request for Additional Information Regarding the Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request," dated November 04, 2021 (ADAMS Accession No. ML21308A507)

In accordance with 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (Exelon) requested changes to the Spent Fuel Pool and Shutdown Cooling Licensing Design Basis of the Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (CCNPP) (Reference 1).

The original proposed changes would revise the Updated Final Safety Analysis Report (UFSAR) Section 9.4, "Spent Fuel Pool Cooling System," design basis to allow for partial and full core offloads without being supplemented with one train of the Shutdown Cooling (SDC) system. In addition, the Spent Fuel Pool (SFP) temperature would be allowed to increase from a maximum of 120 °F and 130 °F for partial and full core offloads, respectively, to a maximum of 150 °F under certain conditions.

On July 20, 2021 NRC announced an Audit Plan to review License Amendment Request (LAR) referenced supporting calculations (Reference 2).

On August 13, 2021 Exelon supplemented the Reference 1 License Amendment Request (LAR) to reduce the LAR scope (Reference 3). The scope of the request was revised to include only full core offloads during refueling outages conducted when the spent fuel pool cooling system (SFPC) service water temperature can be maintained below 50 °F and the SDC system is unavailable to assist the SFPC system, if required.

On October 5, 2021 NRC issued a Request for Additional Information (RAI) (Reference 4) in order to complete their Audit Review of the LAR supporting calculations.

On October 25, 2021, Exelon responded to the RAI (Reference 5). Subsequently, in Reference 6, it was noted by NRC that information requested in Reference 4 for the spent fuel pool liner stresses was not included in the Reference 5 response.

On November 4, 2021 (Reference 7) Exelon responded to the Reference 6 request.

The purpose of this supplement is to provide additional information regarding SFP liner stresses at 212 °F (attached).

Exelon has reviewed the information supporting a finding of no significant hazards consideration, and the environmental consideration, that were previously provided to the NRC in References 1, 3, 5 and 7. Exelon has concluded that the information provided in this response does not affect the bases for concluding that the proposed license amendments do not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92. In addition, Exelon has concluded that the information in this response does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed amendments.

There are no regulatory commitments contained in this response.

In accordance with 10 CFR 50.91, "Notice for public comment; State consultation," paragraph (b), Exelon is notifying the State of Maryland of this response to a request for additional information by transmitting a copy of this letter and its attachment to the designated State Official.

Should you have any questions concerning this submittal, please contact Frank Mascitelli at (610) 765-5512.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 30th day of November 2021.

Respectfully,

_____

David P. Helker
Sr. Manager - Licensing and Regulatory Affairs
Exelon Generation Company, LLC

Attachment: Supplement to the RAI Response for the Spent Fuel Pool Liner Stresses

cc: Regional Administrator, Region I, USNRC
USNRC Senior Resident Inspector, CCNPP
Project Manager [CCNPP] USNRC
S. Seaman, State of Maryland

ATTACHMENT

Calvert Cliffs Nuclear Power Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-53 and DPR-69
Docket Nos. 50-317 and 50-318

Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request

Supplement to the RAI Response for the Spent Fuel Pool Liner Stresses

References:

1. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, “Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request,” dated June 14, 2021 (ADAMS Accession No. ML21165A406)

2. Letter from Michael Marshall, U.S. Nuclear Regulatory Commission to David P. Rhoades, Exelon Generation Company, LLC, “Calvert Cliffs Nuclear Power Plant, Units 1 and 2 – Audit Plan in Support of Review of License Amendment Request Regarding Change Spent Fuel Pool Cooling Design Basis (EPID L-2021-LLA-0112),” dated July 20,2021 (ADAMS Accession No. ML21200A074)

3. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, " Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request Supplement,” dated August 13, 2021 (ADAMS Accession No. ML21225A353)

4. Email from Andrea Mayer, U.S. Nuclear Regulatory Commission, to Francis J. Mascitelli, Exelon Generation Company, LLC, " Request for Additional Information: Calvert Cliffs 1 & 2 LAR to Revise Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Basis (L-2021-LLA-0112)," dated October 5, 2021 (ADAMS Accession No. ML21287A093)

5. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information Regarding the Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request,” dated October 25, 2021 (ADAMS Accession No. ML21298A043)

6. Email from Andrea Mayer, U.S. Nuclear Regulatory Commission, to Francis J. Mascitelli, Exelon Generation Company, LLC, "Re: Calvert Cliffs SFPC-SDC LAR RAI Response," dated November 2, 2021

7. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Supplement to Response to Request for Additional Information Regarding the Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request,” dated November 04, 2021 (ADAMS Accession No. ML21308A507)

By letter dated June 14, 2021, Reference 1, as supplemented by letter dated August 13, 2021, Reference 3, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21165A406 and ML21225A353, respectively), Exelon Generation Company, LLC (Exelon) submitted a license amendment request (LAR) to revise the Updated Final Safety Analysis Report (UFSAR) and the Technical Requirements Manual for Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (CCNPP), to allow for a full core offload in the spent fuel pool (SFP) without being supplemented with one train of the Shutdown Cooling (SDC) system. The proposed amendment also includes a change in the calculational methodology used in the SFP heat-up analysis.

From July 6 to August 29, 2021, the NRC staff conducted a regulatory audit to review licensee calculations supporting the LAR to determine if additional information contained in the analyses performed in support of the requested change is needed to support or develop conclusions for the staff's safety evaluation. An audit plan was issued by the NRC staff by letter dated July 20, 2021, Reference 2 (ADAMS Accession No. ML21200A074).

The Nuclear Regulatory Commission (NRC) staff has determined, during the regulatory audit, that additional information was needed to complete its review of the request (Reference 4). On October 25, 2021 Exelon provided a response to the Request for Additional Information (RAI) (Reference 5). In an email dated November 2, 2021 (Reference 6), NRC indicated that that stresses for the Spent Fuel Pool (SFP) liner were not included in the RAI response. On November 04, 2021 Exelon supplemented the RAI Response (Reference 7). Subsequently, in a telecon on November 09, 2021 between Andrea Mayer (NRC) and Frank Mascitelli (Exelon), the NRC informed Exelon that the SFP liner stresses at 212 °F are required. This supplement to the RAI response provides the requested information involving the SFP liner stresses at 212 °F and a revision to stresses at 155 °F provided in Reference 7. The NRC RAI is shown below in italics:

REQUEST FOR ADDITIONAL INFORMATION

> *"Describe, with quantitative results, how the structural acceptance criteria were met for the SFP walls and its liner for the controlling load combinations including thermal loads."*

Exelon Response:

After further review of the original calculation supporting the Reference 7 response, additional computations were performed to arrive at the below SFP liner buckling stress numbers at the requested temperature values. The additional computations were performed using the same approved calculation methodology to provide the total stresses at different ratios of buckled length to the unbraced length instead of the one ratio previously presented in Reference 7.

The four cases represent spent fuel pool temperatures of 155 °F and 212 °F, with the buckled length equal to either the entire unbraced length between anchor points or 40% of that length. The 40% condition represents a liner that has buckled axially but is pushed back onto the concrete over a portion of that length (60%) due to hydrostatic pressure. All of the loads identified above are within the allowable of 25.2 ksi.

The allowables changed from 18,000 psi in Reference 7 to 25,200 psi because that was what was listed in the original calculation (18,000 psi) instead of using the code documentation (25,200 psi).

The following are the approximate total stresses on the SFP liner:

Load Case	**SFP Temp** (°F)	**Ratio of Buckled Length to Unbraced Length**	**Axial Buckling Load (lbs)**	**Axial Buckling Stress (psi)**	**Critical Shell Buckling Stress (psi)**	**Total Stress (Membrane plus Bending Stress) (psi)**
1	155	1.0	1,216	6,485	0.27	4,523
2	212	1.0	1,084	5,782	0.34	5,427
3	155	0.4	1,668	8,893	6.68	20,424
4	212	0.4	1,503	8,014	8.45	23,994

Note: Yield strength of austenitic stainless steel at 212 °F is 25.2 ksi (USAS B31.7-1969 Table A.3)

Additional Background on Calculation Methodology

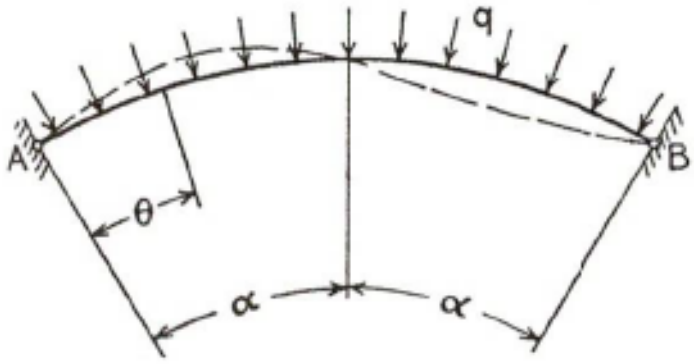
General Philosophy

The overall approach is that as the temperature in the SFP rises above the temperature associated with a zero-stress condition, the differential coefficients of thermal expansion of the stainless steel liner and underlying concrete cause them to expand at different rates. The differential is significant: 9.5 x 10^{-6} in/in/°F for stainless steel (Ref. B31.7-1969), and 5.5 x 10^{-6} in/in/°F for concrete (Ref. “Reinforced Concrete Designer’s Handbook,” 10^{th} Edition, by Reynolds and Steedman). Since the two are connected together at regularly spaced attachment points, and the coefficient of thermal expansion for stainless steel is the higher of the two, the concrete will act to constrain thermal growth of the liner. The result is axial compressive stress in the liner that causes it to buckle in the manner shown below, where P is the axial load due to differential thermal expansion and l is the distance between attachment points to the concrete.

Timoshenko "Theory of Elastic Stability, 2nd Edition, Figure 2-36 (Page 91)

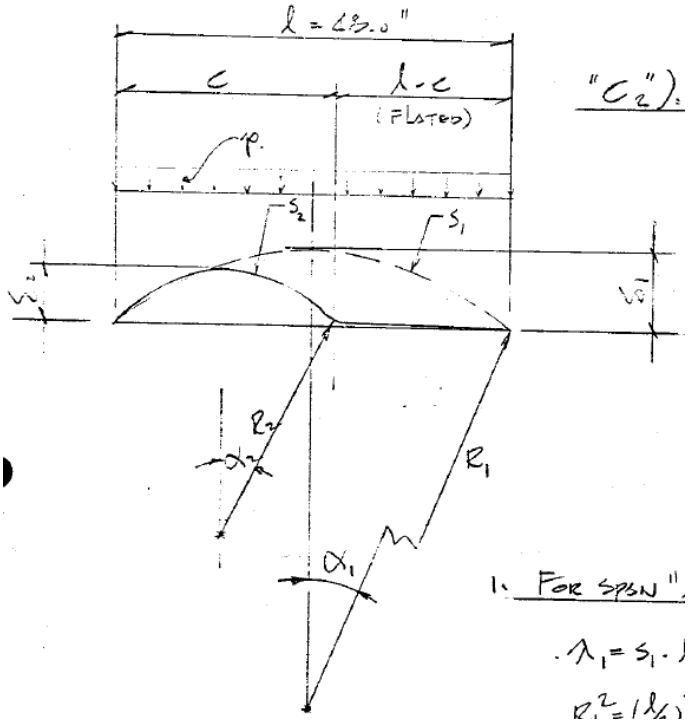
Above the waterline or at shallow depths where the hydrostatic pressure is low, the buckled shape shown above can form quite easily. However, as depth increases, the hydrostatic pressure counters the lateral deflection.

The resulting effect is uniform compression of a circular arch, and if the hydrostatic pressure is high enough, buckling will occur as shown below:



Timoshenko Figure 7-11 (Page 297)

Since the inward buckled portion of the arch comes into contact with the surface of concrete, the full buckled shape is unable to form, and the resulting shape:



The original length is l, and the initial axially buckled shape is curve S_1, but hydrostatic pressure has caused buckling of the arch that results in length $(l - c)$ laying flat against the concrete. As a result, the effects of all thermal growth over length l are now concentrated within the shorter buckled length c. The buckled length and the amplitude of the buckle for curve S_2 will determine the radius R_2 and α_2, the angle of the arc, both of which are parameters in the equation for critical buckling stress for the arch:

$$q_{cr} = \frac{EI}{R^3}\left(\frac{\pi^2}{\alpha^2} - 1\right)$$

Timoshenko Equation 7-20 (Page 297)

In turn, the critical buckling stress q_{cr} and the radius of the arc R_2 are both parameters in the equation for total stress, which is the sum of the membrane (hoop) stress and the bending stress:

$$\sigma_t = \sigma_m + \sigma_b = \frac{q_{cr}R_2}{t} + \frac{Et}{2R_2}$$

The shorter the buckling length, the higher the deflection amplitude and the higher the critical buckling stress and total stress, so the collapse effect under hydrostatic load is important. The axial buckling and arch buckling progresses until critical buckling stress exceeds hydrostatic pressure and the arch is stable.

Preliminary Load and Stress Result Summary

Load Case	SFP Temp (°F)	Ratio of Buckled Length to Unbraced Length	Axial Buckling Load (lbs)	Axial Buckling Stress (psi)	Critical Shell Buckling Stress (psi)	Total Stress (Membrane plus Bending Stress) (psi)
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