FPL

L-2019-067
10 CFR 54.17

March 21, 2019

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

Re: Florida Power & Light Company
Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Turkey Point Units 3 and 4 Subsequent License Renewal Application
Safety Review Revision 1 Requests for Additional Information (RAI)
Third Submittal Set 8 Response

References:

1. FPL Letter L-2018-004 to NRC dated January 30, 2018, Turkey Point Units 3 and 4 Subsequent License Renewal Application (ADAMS Accession No. ML18037A812)
2. FPL Letter L-2018-082 to NRC dated April 10, 2018, Turkey Point Units 3 and 4 Subsequent License Renewal Application – Revision 1 (ADAMS Accession No. ML18113A134)
3. NRC RAI E-Mail to FPL dated February 1, 2019 – Revision 1 Requests for Additional Information for the Safety Review of the Turkey Point Subsequent License Renewal Application – Set 8 (EPID No. L-2018-RNW-0002) (ADAMS Accession Nos. ML19032A397 and ML19032A616)
4. NRC Public Meeting Agenda dated February 25, 2019 for the March 7, 2019 Meeting Between NRC and FPL Regarding the Turkey Point Subsequent License Renewal Application (ADAMS Accession No. ML19059A379)
5. FPL Letter L-2019-033 to NRC dated March 1, 2019, Turkey Point Units 3 and 4 Subsequent License Renewal Application Safety Review Revision 1 Requests for Additional Information (RAI) Set 8 First Submittal Responses (ADAMS Accession No. ML19064A824)
6. FPL Letter L-2019-048 to NRC dated March 15, 2019, Turkey Point Units 3 and 4 Subsequent License Renewal Application Safety Review Revision 1 Requests for Additional Information (RAI) Set 8 Second Submittal Responses
7. NRC RAI E-Mail to FPL dated February 22, 2019 – Response Date Extension for RAIs Set 8, Revision 1, for the Safety Review of the Turkey Point Subsequent License Renewal Application (EPID No. L-2018-RNW-0002) (ADAMS Accession Nos. ML19032A396 and ML19032A397)

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8. FPL E-Mail to NRC dated March 15, 2019, Schedule for Submittal of the SLRA Safety Review Revision 1 RAI Third Submittal Set 8 Response

Florida Power & Light Company (FPL) submitted a subsequent license renewal application (SLRA) for Turkey Point Units 3 and 4 to the NRC on January 30, 2018 (Reference 1) and SLRA Revision 1 on April 10, 2018 (Reference 2).

The purpose of this letter is to provide, as an attachment to this letter, the response to the one remaining safety review revision 1 Set 8 RAI issued by the NRC on February 1, 2019 (Reference 3). This response has been informed by discussions held during the March 7, 2019 NRC public meeting (Reference 4). The response attachment identifies revisions amending the SLRA.

The other 14 safety review revision 1 Set 8 RAI responses were provided in FPL's first and second submittals dated March 1, 2019 and March 15, 2019 (References 5 and 6). The NRC established the schedule for submittal of the revision 1 Set 8 RAI responses in Reference 7. FPL informed the NRC of the revised submittal date for this RAI response in Reference 8.

If you have any questions, or need additional information, please contact me at 561-691-2294.

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

Executed on March 21, 2019.

Sincerely,

William Maher
Senior Licensing Director
Florida Power & Light Company

WDM/RFO

Attachment: FPL Response to Follow-on NRC RAI No. 3.5.2.2.2.6-11

cc:

Senior Resident Inspector, USNRC, Turkey Point Nuclear
Regional Administrator, USNRC, Region II
Project Manager, USNRC, Turkey Point Nuclear
Plant Project Manager, USNRC, SLRA
Plant Project Manager, USNRC, SLRA Environmental
Ms. Cindy Becker, Florida Department of Health

NRC RAI Letter Nos. ML19032A396 and ML19032A397 Dated February 1, 2019

RAI 3.5.2.2.2.6-11

Regulatory Basis

10 CFR 54.21(a)(3) requires the applicant to demonstrate that the effects of aging for structures and components will be adequately managed so that the intended function will be maintained consistent with the current licensing basis, for all structures and components (SCs) that have been scoped and screened-in for subsequent license renewal, for the subsequent period of extended operation. As described in SRP-SLR, an applicant may demonstrate compliance with 10 CFR 54.21(a)(3) by referencing the GALL-SLR Report and when evaluation of the matter in the GALL-SLR Report applies to the plant. SRP-SLR Section 1.2.1 notes that the SRP-SLR and GALL-SLR Reports do not provide a comprehensive list of all potential aging effects that may be applicable to structures subject to an Aging Management Review (AMR). Therefore, applicants should perform plant-specific AMRs for additional aging effects that are applicable. Branch Technical Position A.1.2, in Appendix A of the SRP-SLR, provides additional guidance on identifying applicable aging effects.

SRP-SLR Section 3.5.2.2.2.6 states that reduction of strength, loss of mechanical properties, and cracking due to irradiation could occur in PWR Group 4 concrete structures (e.g., reactor (primary/biological) shield wall, the sacrificial shield wall, and the reactor vessel support/pedestal structure) that are exposed to high levels of neutron and gamma radiation. The SRP-SLR recommends further evaluation of a plant-specific program to manage aging effects of irradiation if the estimated (calculated) fluence levels or irradiation dose received by any portion of the concrete (also referred to as reinforced/composite concrete) from neutron (fluence cutoff energy E > 0.1 MeV) or gamma radiation exceeds the SRP-SLR threshold levels during the subsequent period of extended operation or if plant-specific operating experience (OE) of concrete irradiation degradation exists that may impact intended functions.

Background:

The SRP-SLR states that data related to the effects and significance of gamma radiation on concrete mechanical and physical properties is limited, especially for conditions (e.g., dose, temperature) representative of light-water reactor (LWR) plants. The SRP-SLR also states that based on literature review of existing research, a radiation limit of $1x10^8$ Gy ($1x10^{10}$ rad) gamma dose is considered a conservative radiation exposure level beyond which concrete material properties may begin to degrade markedly.
SLRA Section 3.5.2.2.2.6, as supplemented by letter dated October 5, 2018, states that Figure 7 of Hilsdorf (1978) paper "presented the change in compressive strength versus gamma dose for a limited amount of data." The SLRA also states that "[t]he mean interpolated value of the trend of this data would indicate a decrease in compressive strength for a dose between 2.0×10^{10} rads to 3.0×10^{10} rads. However, the data that was used to derive the plot is varied and not considered as fully representative of commercial reactor conditions." The SLRA further states the following:

The Maruyama (2017) paper (Reference 1) suggested that either the threshold reference value for gamma exposure be raised to a high level or abandoned entirely. With consideration of the prior Hilsdorf data and the available test data presented by Maruyama, the test data indicates gamma irradiation up to and beyond a threshold of 2.3×10^{10} rads has no effect on material properties. Based on the above discussion, and considering the 80 year gamma dose incident on the primary shield wall at PTN is 1.9×10^{10} rads, there will be no degradation of the primary shield concrete at PTN due gamma radiation.

Issue:

The staff noted that the SLRA references Maruyama's (2017) study, which uses a gamma dose threshold of 2.3×10^{10} rads, as the basis to conclude that there will be no degradation of the PTN PSW concrete due to gamma radiation since PTN's gamma dose is 1.9×10^{10} rads. It is not clear to the staff how Maruyama (2017) findings are a justified approach for screening out the effects of gamma radiation on PTN's PSW concrete when the SRP-SLR threshold for damage is 1.0×10^{10} rads. In its review of the referenced study, the staff noted the following:

- **gamma dose rate:** the staff noted uncertainties on the applicability of test results relevant to gamma dose radiation of concrete in nuclear power plants (NPPs). For example, in Maruyama (2017) studies, concrete specimens were exposed to gamma ray dose rates 2-20 times greater (1.25 to 10 kGy/h) than expected at concrete components near a PWR reactor vessel (approx. 500 Gy/h). In that regard, Murayama's paper (2017) states that "it is impossible, in principle, to determine whether the obtained data can be applied to commercial reactors without assessing the effects of dose-rate." Also, in its conclusion summary of results for gamma-ray impact on concrete Maruyama (2017) states that "the findings reported in this work must be validated to ensure their reproducibility. [...] After validation, the reference values for gamma rays should be abandoned."

- **carbonation of concrete:** Murayama's paper (2017) notes that "[o]nly when concrete is carbonated under irradiation will its strength increase," and that "[t]here was almost no difference between gamma ray-irradiated and heat dried specimens exposed to conditions under which carbonation typically proceeds," noting the need for "[a]dditional gamma-ray irradiation tests on concrete without carbonation." The paper then concludes that "[w]hen supplemental drying tests under non-CO_2 conditions were performed [...] strength of those specimens quickly fell as the mass reduction rate increased, faster than the strengths of gamma-ray-irradiated and heat dried specimens." It is not clear to staff whether the applicant has taken into consideration the impact of carbonation, heating and drying on the results in Maruyama's paper (2017) and if and how that relates to the conditions on the concrete at PTN PSW concrete. Absent conditions suitable for carbonation of the concrete it is not clear how the applicant concludes that no loss of strength is expected due to gamma irradiation.

- **temperature:** The staff also noted that the test temperature of the Maruyama study specimens was lower (10 to 30 degrees Celsius) than the operating temperature for the concrete at PTN's PSW (approximately 49 degrees Celsius). The staff notes that at higher temperatures more degradation due to irradiation is expected due to an increase in thermal stresses of concrete.

- **cement type and w/c ratio:** The staff noted that PTN's concrete is composed of ASTM C-150-64 Florida Type II cement with a w/c ratio of 0.59, as reported in the SLRA and Supplement FPLCORP020-REPT-130, Revision 1, while Maruyama's gamma radiation tested concrete specimens used early high strength Type I cements with a much lower w/c ratio of 0.50. It is not clear if and how the gamma radiation induced aging effects (e.g.., radiolysis) of the Maruyama tested concrete specimens with a lower w/c ratio compare to the cast concrete of higher w/c ratio at PTN's PSW.

Based on both apparent dissimilarities between PTN concrete and that used in the Maruyama study and lack of consideration of some factors, it is not clear to staff if and how the Maruyama (2017) study test results for gamma dose aging effects on concrete are relatable and applicable to PTN PSW concrete. The staff needs additional information to justify the applicant's assumption that there are no aging effects on concrete due to interactions of gamma rays with cement paste and aggregate used in PTN concrete during the SPEO.

Request:

With regard to considerations such as the gamma dose rate, carbonation of concrete, aggregate, cement type, w/c ratio, and operating temperature of the concrete at PTN PSW versus the test specimens used in the Maruyama study: explain how the conclusions in Maruyama's paper can be used to assume that there is no degradation in material properties due to gamma dose, or provide justification for why such comparison between the PTN PSW and Maruyama study is unnecessary.

FPL Response:

As discussed during the March 7, 2019 NRC public meeting, the comparison of the PTN PSW concrete to that used in the Maruyama (2017) is unnecessary. The evaluation of the effects of gamma dose above the conservative threshold of 1.0×10^{10} rad specified in NUREG-2192 is provided below. This evaluation supplements the discussion provided in Reference 1 and the discussion during the public meeting on March 7, 2019. Furthermore, SLRA commitment 53 remains to follow related industry efforts and develop an informed aging management program if appropriate.

To evaluate the reduction in concrete strength due to gamma based on the 1.0×10^{10} rad threshold, the combination of both neutron and gamma effects need to be addressed. The PTN PSW was previously evaluated for the RIVE and neutron radiation effects (i.e., strength and modulus reductions) on the concrete. The corresponding maximum IR was calculated to be 0.82 for the governing load case (faulted with new-LOCA) as described in the response to RAI 3.5.2.2.2.6-12 (Ref. 2, Attachment 6).

The PTN calculated gamma dose for 80 years is 1.9 x 10^{10} rad (Ref. 1) at the air-side surface of the PSW. Per page 7 of 19 of Ref. 1, this gamma dose is reduced to 1.0 x 10^{10} rad at a depth of 10.1 inches from the air-side surface of the PSW. From Hilsdorf et al. (see the lower bound curve of the concrete strength reduction due to gamma dose on page 11 of 19 of Ref. 1), a conservative estimate of the strength reduction in the PSW concrete based on 1.9 x 10^{10} rad is 10% at the air-side surface decreasing to zero at the depth of 10.1 inches. The effect of this concrete strength reduction on the ability of the PSW to accommodate compressive and tensile stresses is evaluated below.

The maximum compressive stress in the PTN PSW for the governing load case (faulted with new-LOCA per Ref. 2, Attachment 6) was calculated to be less than 1,000 psi per the evaluation report of the effect of radiation on the PSW and supports available on the ePortal. The PTN PSW has greater than 10% design margin for the compressive stress (IR = 0.65 for the maximum compressive stress including neutron effects). Thus, the 10% strength reduction for the first 10.1 inches of the PSW due to gamma radiation is less than the available design margin of 35% (= 1 – 0.65) for compressive stress and thus is considered acceptable.

Because the maximum IR of 0.82 (including the RIVE and neutron radiation effects) was calculated for tension, the strength reduction due to the gamma dose and its effects on the elastic modulus of the concrete need to be evaluated. The concrete modulus is related to the square root of the concrete compressive strength, and the 10% reduction in strength due to gamma, results in a concrete modulus reduction of 5.1% (= $1 - \sqrt{0.9}$). This modulus reduction in the first 10.1" requires the evaluation of additional rotational deformation of the PSW. To simulate this effect, additional (internal) stresses (10% of the maximum compressive stress) are added to the irradiated concrete section of the PSW. For this simulation, the stress is applied uniformly to the first 10.1 inches of the section (this is conservative since the reduction is gradually decreased to zero at the depth of 10.1 inches. Also using the 10% additional internal stress is conservative since the 5.1% elastic modulus reduction is bounded by the 90-day elastic modulus increase of 58%, i.e. = $1 - \sqrt{7500psi \div 3000psi}$). The additional (internal) stress and moments are calculated as follows:

Additional internal stress = 10% x 1,000 psi x 12" x 10.1" (for 12" unit width) = 12.12 kip

Additional moment = 12.12 kip x (55.56" - 10.1"/2)/12 = 51 kip-ft

(where, 55.56" is the distance from the center of the additional stress to the neutral axis of the irradiated concrete section per the evaluation report of the effect of radiation on the PSW and supports available on the ePortal)

The above additional moment results in an approximate 8.7% increase above the total moment previously calculated for neutron effects. Using the same analysis approach as described in the response to RAI 3.5.2.2.2.6-12 (Ref. 2, Attachment 6) for the governing load case (faulted with new-LOCA per Ref. 2, Attachment 6), the maximum IR including the additional moment for the modulus reduction due to the gamma effect is calculated to be 0.89.

Comparing to the IR of 0.82 (without considering the gamma effect), the maximum IR is increased by 8.5% (= 0.89/0.82 - 1) but less than 1.0. These evaluation results are conservative based on the following:

1. The 10% reduction in concrete strength is applied uniformly to the entire 10.1" from the air-side surface of the PSW, whereas the 10% reduction in strength decreases to zero at the depth of 10.1 inches.

2. The 10% reduction in concrete strength is applied equally above and below the reactor core mid-height for the full active length of the nuclear fuel (~12'). In reality, based on typical axial gamma flux distribution, areas of concrete above and below the core mid-height will be exposed to lower gamma doses and correspondingly, less strength reduction.

3. For the PTN primary shield wall concrete, strength is specified as 3,000 psi at 28 days, and 7,500 psi at 90 days. Thus, the 10% reduction in concrete strength will be bounded by the 90-day concrete strength, which was not accounted for in the evaluation.

4. The Westinghouse-calculated PTN gamma dose at the end of the SPEO provided in the response to RAI 3.5.2.2.2.6-2 (Ref. 3, Attachment 2) is 1.44×10^{10} rad compared to 1.9×10^{10} rad used above. Similarly, a strength reduction of 7% corresponding to the gamma dose of 1.44×10^{10} rad is calculated based on the Hilsdorf et al. (1978) lower bound curve for the gamma dose on page 11 of 19 of Ref. 1. It is also calculated that the 7% strength reduction is decreased to zero at a depth of 7 inches that is calculated by using the linear interpolation of the gamma dose information table (provided in Reference 1, Pg. 7 of 19). Thus, the use of the Westinghouse-calculated number results in the smaller strength reduction as well as the smaller section of the affected concrete.

5. Implementation of auxiliary line leak-before-break will significantly reduce the design loading, which has been requested as part of this SLRA.

As shown above, sufficient margin in the design of the PTN PSW exists to accommodate the impact of the gamma radiation calculated for PTN at the end of the SPEO which is above the threshold of 1.0×10^{10} rad used in the guidance. In addition, the evaluation identified several conservatisms which provide reasonable assurance that the PTN PSW concrete will be able to perform its intended function. Therefore, the comparison of the PTN PSW concrete to that used in the Maruyama (2017) is unnecessary, and the intended function of the PTN PSW considering both neutron and gamma radiation will be maintained for the SPEO. However, as the potential for irradiation-related degradation cannot be fully eliminated, FPL is committing to follow the on-going industry efforts, such as through EPRI, that are clarifying the effects of irradiation on concrete and corresponding aging management recommendations as noted in Commitment Number 53 in Table 17-3 of Rev. 1 of the PTN SLRA.

Revisions to SLRA Section 3.5.2.2.2.6 (attachment to Ref. 1) as a result of this gamma evaluation are provided below.

References:

1. FPL Letter L-2018-187 to NRC dated October 5, 2018, Turkey Point Units 3 and 4 Subsequent License Renewal Application Revision to SLRA Section 3.5.2.2.2.6, Reduction of Strength and Mechanical Properties of Concrete Due to Irradiation (ADAMS Accession No. ML18283A308)

2. FPL Letter L-2019-012 to NRC dated February 13, 2019, Turkey Point Units 3 and 4 Subsequent License Renewal Application Review Revision 0 Requests for Additional Information (RAI) Set 8 Responses (ADAMS Accession No. ML19050A400)

3. FPL Letter L-2019-048 to NRC dated March 15, 2019, Turkey Point Units 3 and 4 Subsequent License Renewal Application Safety Review Revision 1 Requests for Additional Information (RAI) Set 8 Second Submittal Responses

Associated SLRA Revisions:

SLRA Section 3.5.2.2.2.6, Rev. 1 (Attachment to Reference 1) is amended as indicated by the following text deletion (strikethrough) and text addition (red underlined font) revisions.

Revise SLRA Section 3.5.2.2.2.6, Rev. 1, Page 12 of 19 (Revise the 1st and 2nd paragraph) of Reference 1 as follows:

The Maruyama paper suggested that either the threshold reference value for gamma exposure be raised to a high level or abandoned entirely **with further verification**. With consideration of the prior Hilsdorf data and the available test data presented by Maruyama **and as described in NUREG/CR-7171**, the test data indicates gamma irradiation up to ~~and beyond a threshold of~~ 2.3 x 10^{10} Rads **likely** has no effect on material properties.

Based on the above discussion, and considering the 80 year gamma dose incident on the primary shield wall at PTN is 1.9 x 10^{10} Rads **being greater than 1 x 10^{10} Rads set by the regulator**, there will **likely** be no **or minimal** degradation of the primary shield concrete at PTN due to gamma radiation. However, FPL will continue to follow EPRI and industry efforts to better define the effects of gamma radiation on concrete, and will update this evaluation and implement a**n informed** plant specific AMP**, consistent with industry finding relative to gamma irradiation,** if necessary as noted in Commitment Number 53 in Table 17-3 **to provide reasonable assurance that the PSW will perform its intended function through the subsequent period of extended operation**.

Revise the SLRA Section 3.5.2.2.2.6, Rev. 1, conclusion statement beginning on Page 17 of the Attachment to Reference 1 as follows:

Based on the above, a plant-specific program to manage the effects of concrete irradiation **on its strength and mechanical properties** is not expected to be necessary to ensure the components perform their intended function consistent with the CLB through the subsequent period of extended operation. However**, as the potential for irradiation-related degradation cannot be fully eliminated,** FPL **is committing to more frequent inspections of the RV supports under the ASME Section XI, Subsection IWF AMP, and** will continue to follow the on-going industry efforts**, such as through EPRI,** that are clarifying the effects of irradiation ~~of~~ **on** concrete and corresponding aging management recommendations as noted in Commitment Number 53 in Table 17-3, and will:

a) ensure their applicability to the PTN Unit 3 and Unit 4 primary shield wall and associated reactor vessel supports;

b) update design calculations, as appropriate; and

c) develop an informed plant-specific program, if needed.

Associated Enclosures:

None