SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS

RELATED TO AMENDMENT NO. 14 TO THE COMBINED LICENSE NO. NPF-93

AND LICENSE NO. NPF-94

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

SOUTH CAROLINA PUBLIC SERVICE AUTHORITY

VIRGIL C. SUMMER NUCLEAR STATION UNITS 2 AND 3

DOCKET NOS. 52-027 AND 52-028

1.0 INTRODUCTION

By letter dated April 3, 2014 (Agencywide Documents Access and Management System (ADAMS) under Accession No. ML14093B258), South Carolina Electric & Gas Company (SCE&G/ licensee) submitted a request for a license amendment request (LAR) for the Virgil C. Summer Nuclear Station (VCSNS), Units 2 and 3. The proposed license amendment request would depart from the plant-specific Design Control Document (DCD) Tier 2* material to identify design details of the floors of the auxiliary building that may vary due to design and loading conditions, in accordance with code requirements. The licensee stated that:

- These changes are primarily for constructability and the changes identify how the floors other than the critical sections vary from the detail design shown on the update safety analysis report (UFSAR) figures.
- Notes are added to the figures to describe the specific variations in the detail design.
- The variations in the detail design, which include information such as size and spacing of reinforcement in the floors and the span of the floors, are the result of variations in the geometry of the floors and variations in the loads for which the floors are designed.

In a letter dated May 19, 2014 (ADAMS Accession No. ML14139A080), the licensee provided additional information that clarified the application, did not expand the scope of the application as originally noticed and did not change the staff's original proposed "no significant hazards consideration" determination published in the *Federal Register* on April 29, 2014 (79 FR 24024).

2.0 REGULATORY EVALUATION

Appendix D, "Design Certification Rule for the AP1000 Design," of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Section VIII.B.6 requires NRC approval for departures from Tier 2* information. Because the proposed amendment request involves changes to Tier 2* information NRC approval is required before making the Tier 2* changes addressed in this departure.

The NRC staff considered the following regulatory requirements in reviewing the LAR that included the proposed UFSAR changes.

10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 1, "Quality Standards and Records," requires that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of safety functions to be performed.

10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena," requires that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Basis," requires that structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-cooling accidents.

3.0 TECHNICAL EVALUATION

To perform the technical evaluation, the NRC staff considered UFSAR Appendix 3H, "Auxiliary and Shield Building Critical Sections." The staff also examined portions of NUREG–1793, Supplement 2, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Plant Design" (NUREG-1793) (ADAMS Accession No. ML112061231), and "Virgil C. Summer Nuclear Station, Final Safety Evaluation Report," (ADAMS Accession No. ML110450305) documenting the staff's technical evaluation of those aspects of the AP1000 Design Control Document (DCD) and VCSNS COL application, respectively. The staff reviewed the proposed LAR 14-01 (herein to forth referred to as the LAR), to evaluate the impact of the requested UFSAR changes on the safety function of the nuclear island (NI) structures to be constructed at the VCSNS site.

In the LAR, the licensee proposed to depart from the plant-specific DCD Tier 2* information by revising UFSAR Appendix 3H to (1) clarify critical section descriptions in Subsections 3H.1 and 3H.5 for consistency between descriptions and numbers for critical sections in Figure 3H.5-1, (2) enhance the description of composite floors in Subsection 3H.5.2 and Figure 3H.5-6, and (3) enhance the description of concrete floors in Subsection 3H.5.3 and Figure 3H.5-8. The licensee stated that proposed changes do not impact thicknesses of auxiliary building floors. The staff's technical evaluation of items (1) and (2) is discussed in the next section of this report and the evaluation of item (3) is discussed in the section titled, "*Reinforced Concrete Floor System.*"

Clarification of Critical Section Descriptions

In Enclosure 1 of the LAR, the licensee describes UFSAR revisions made to clarify information relating to critical section figures and add information describing the design of the auxiliary building composite floor system. The licensee proposes changes to UFSAR Subsections 3H.1 (second paragraph), 3H.5 (first paragraph), 3H.5.2 (first and second paragraphs), and 3H.5.2.2 (first paragraph).

The licensee states that the proposed changes revise the descriptions of the design of the auxiliary building floors and the associated figures to change the descriptions of the floor structures to identify and describe how detail design information varies in the floor locations other than critical sections. The descriptions of the floors are rewritten to separate the general description of the floor design from the description of the critical sections. The licensee also describes that the proposed changes in the description identify and describe differences between the critical section design and the design of similar floors in other locations.

The NRC staff performed a review of the above UFSAR changes and found the changes to be acceptable on the basis that the commitment to design the auxiliary building floor systems in accordance with ACI 349 and AISC N690 remains unchanged, and that the proposed changes enhance the clarity of the description of the floor system design for both critical sections and areas outside of the critical sections.

Reinforced Concrete Floor System

UFSAR Subsection 3H.5.3 describes the design of reinforced concrete floor slabs (i.e., cast-in-place concrete over precast concrete panels). These floors are constructed with 16 inch or 28 inch reinforced concrete placed on top of 8 inch thick precast concrete panel for a total floor thickness of 24 inch or 36 inch. The main reinforcement is provided in the precast panels. Further, these precast panels are connected to the concrete placed above it by shear reinforcement.

In Enclosure 1 of the LAR, the licensee describes changes to UFSAR Subsection 3H.5.3 to revise the description of the design of floors and to change the description of the reinforced concrete slabs. In addition, the changes identify how information for structural design varies in locations other than the critical sections.

Proposed changes include ranges of thickness for precast panels, removal of precast panel anchorage to adjacent walls, and re-location of main flexural reinforcement (including anchorage to adjacent walls) to the cast-in-place concrete slab. Edits are also proposed to include relevant design considerations for reinforcement development, anchorage, seismic detailing, and composite action between the precast panel and the cast-in-place slab. For precast panels, the LAR provided expected variations in spans and widths, as well as maximum number of panels side by side. It is also explained that there will be a 0.5-inch gap between panels and between panels and walls. Precast panels are to serve as formwork for the cast-in-place concrete slab and for radiation protection. Precast panels and cast-in-place slab are connected by shear reinforcement and are designed to act compositely by means of both shear reinforcement and roughening of precast panel top surfaces. The LAR explained that post-construction loads are conservatively assumed to be resisted by the cast-in-place portion of the floor. That is, the cast-in-place section (concrete and reinforcement) is designed to resist all design basis demands for the floor and floor-to-wall connection without reliance on strength contribution and load carrying capacity of the precast panel section.

In Enclosure 1 to the LAR, the licensee describes analysis performed to assess the impact of the proposed changes on the dynamic response of the AP1000 nuclear island (NI). The LAR describes that the design basis auxiliary building finite element analysis (FEA) model assumes homogeneous floor units of thickness equivalent to the combination of the cast-in-place and precast panels thicknesses. Further, the LAR states that these floors are modeled with linear elastic properties, including an 80 percent reduction of the reinforced concrete modulus of elasticity to reflect the observed behavior of concrete under safe shutdown earthquake stresses. In order to evaluate the impact of the proposed concrete floors design changes on the NI dynamic response, the licensee performed a series of more detailed FEAs that explicitly addressed the proposed design changes as described below. Specifically, these analyses were performed to demonstrate that the 80 percent effective modulus of elasticity used on the design basis FEA models remains acceptable and that the floor natural frequency is not degraded below the AP1000 certified seismic design response spectra (CSDRS) minimum cut-off frequency of 33 Hertz (Hz) for rigid structures.

Different configurations of panel thicknesses, spans, and aspect ratios for one-way and two-way floors were considered in the analyses. Out of these combinations, a bounding floor configuration was selected based on the longest span with highest ratio of precast to cast-in-place thickness. The FEA models developed for this bounding case included combinations of one-way and two-way models with and without modeling of gaps, linear models with an initial assumption of 80 percent effective modulus, and non-linear models capable of predicting concrete cracking. These models were subjected to a combination of loads that included a beyond design basis seismic load equivalent to 1.67 times the AP1000 CSDRS. As stated in the LAR, linear and non-linear displacement results compared favorably therefore demonstrating that the use of an 80 percent effective modulus remains appropriate. Further, the licensee determined a bounding reduced effective modulus equivalent to 53 percent effective modulus by reducing the effective modulus of a one-way linear model without gaps as to achieve the displacement results of an overall bounding one-way non-linear model with gaps.

Subsequently, this bounding reduced modulus was used in a modal analysis of the design basis floor FEA model to determine a bounding reduced floor vertical natural frequency. As stated in the LAR, the use of 53 percent effective modulus resulted in a bounding reduced vertical natural frequency of 37 Hz therefore demonstrating that the floor vertical response remains within the rigid range of response (i.e., natural frequencies above 33 Hz). Additionally, based on a comparison to the design basis response spectra analysis, the LAR states that the bounding reduced effective modulus results in insignificant changes to the seismic force demand.

Staff performed a review of the licensees proposed changes to UFSAR subsection 3H.5.3 and finds them to be to be acceptable on the basis that the commitment to design the auxiliary building floor systems in accordance with ACI 349 and AISC N690 remains unchanged, and that the proposed changes enhance the clarity of the description of the floor system design for both critical sections and areas outside of the critical sections. In addition, the staff finds that the licensee's analysis demonstrated that while out-of-plane floor stiffness is reduced, the natural frequency of the panel remains above the AP1000 CSDRS cutoff frequency of 33 Hz and is, therefore, essentially rigid. Hence, there is no impact of the design change on dynamic response of the NI. Staff also performed an independent assessment of the dynamic behavior of the proposed change using simplified finite element models. These analyses confirmed that the proposed changes result in insignificant impact to the dynamic behavior of the AP1000 NI.

3.4 Conclusions

Based on the staff's technical evaluation, the staff finds that:

- The proposed changes to Subsections 3H.1, 3H.5, 3H.5.2 and related figures (3H.5-1, 3H.5-6) are acceptable on the basis that the commitment to design the auxiliary building floor systems in accordance with ACI 349 and AISC N690 remains unchanged, and that the proposed changes enhance the clarity of the description of the floor system design for both critical sections and areas outside of the critical sections and therefore, the requirements of GDC 1 continue to be met.

- The proposed changes to Subsection 3H.5.3 (and related Figure 3H.5-8) are acceptable on the basis that the commitment to design the auxiliary building floor systems in accordance with ACI 349 and AISC N690 remains unchanged, and that the proposed changes enhance the clarity of the description of the floor system design for both critical sections and areas outside of the critical sections and therefore, the requirements of GDC 1 continue to be met.

- The licensee's analysis, performed using the design basis seismic models, demonstrated that while out-of-plane floor stiffness is reduced, the natural frequency of the panel remains above the AP1000 CSDRS cutoff frequency of 33 Hz, where there is no amplification in structural response. Hence, there is no impact of the change on dynamic response of the NI and therefore the requirements of GDC 2 and 4 continue to be met.

For the reasons specified above, the staff finds the proposed UFSAR amendments to Subsections 3H.1, 3H.5, 3H.5.2, and 3H.5.3, acceptable. Similarly, the staff finds the proposed UFSAR amendments to Figures 3H.5-1, 3H.5-6, and 3H.5-8, acceptable. Changes will not affect the analysis results and related conclusions presented in the AP1000 DCD and the VEGP UFSAR related to NI floor design and seismic analysis.

Consequently, the NRC staff concludes that there is reasonable assurance that the requirements of GDC 1, 2 and 4 of Appendix A to 10 CFR Part 50, and Appendix D (Section VIII B6) to 10 CFR Part 52 will continue to be met. Therefore, the staff finds the proposed changes acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations in 10 CFR 50.91(b)(2), the South Carolina State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20, "Standards for Protection Against Radiation." The NRC staff has determined that the amendment involves no significant change in the types or significant increase in the amounts of any effluents that may be released off site. Also, that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (*Federal Register* (FR) notices published on April 29, 2014 (79 FR 24024). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The staff has concluded, based on the considerations discussed in Section 3.0, that there is reasonable assurance that (1) the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public. Therefore, the staff finds the changes proposed in this license amendment request acceptable.

7.0 REFERENCES

1. Request for License Amendment – Auxiliary Building Structural Floor Details (LAR 14-01), letter from South Carolina Electric & Gas Company (SCE&G) dated April 3, 2014 (ADAMS Accession No. ML14093B258) and supplemented by the letter dated May 19, 2014 (ADAMS Accession No. ML14139A080).

2. Virgil C. Summer Nuclear Station, Updated Final Safety Analysis Report, Revision 1, dated July 11, 2013 (ADAMS Accession No. ML13217A253)

3. Virgil C. Summer Nuclear Station, Final Safety Evaluation Report, dated August 17, 2011 (ADAMS Accession No. ML110450305).

4. AP1000 Design Control Document Revision 19, dated June 13, 2011 (ADAMS Accession No. ML11171A087).

5. Final Safety Evaluation Report Related to Certification of the AP1000 Standard Plant Design, Supplement 2, NUREG-1793, dated August 5, 2011 (ADAMS Accession No. ML112061231).

6. American Concrete Institute (ACI), ACI-349-01, "Building Code Requirements for Nuclear Safety Related Structures."

7. American Institute of Steel Construction (AISC), AISC-N690-1994 "Specification for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities."