SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS

RELATED TO AMENDMENT NO. 1 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 January 15, 2013, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13017A082), South Carolina Electric & Gas Company (SCE&G/Licensee) requested that the U.S. Nuclear Regulatory Commission (NRC) amend the combined licenses (COLs) for Virgil C. Summer Nuclear Station Units 2 and 3 (VCSNS), COL Numbers NPF-93 and NPF-94, respectively. The proposed amendment would depart from the VCSNS plant-specific design control document (DCD) Tier 2* information by clarifying the structural criteria details for shear reinforcement bar spacing within the nuclear island (NI) basemat. Subsection 3.8.5.5, Structural Criteria, of the updated Final Safety Analysis Report (UFSAR) currently includes provisions for basemat shear reinforcement that refer to provisions in ACI 349-01, "Code Requirements for Nuclear Safety Concrete Structure," Subsection 11.8.3, for continuous deep flexural members. The UFSAR commits to these provisions without exception or qualifications. These referenced provisions from ACI 349 Subsection 11.8.3 include a maximum spacing requirement on the shear reinforcement. The licensee stated that the maximum spacing provision in ACI 349 Subsection 11.8.3 is not applicable to the AP1000 basemat design and is different than the design as depicted in UFSAR Figures 3H.5-3 and 3.8.5-3 (Sheet 7 of 7), which provide the maximum design spacing for shear reinforcement in the basemat. The licensee also stated that the proposed change resolves the inconsistency in the current licensing basis documents.

To address this issue, the licensee proposed to revise the third paragraph in the UFSAR Subsection 3.8.5.5 to remove the direct reference to ACI 349-01 Subsection 11.8.3 and replace it with supplemental provisions based on criteria from ACI 349-01. The provisions for the spacing of the shear reinforcement are modified to be consistent with the basemat design included in the UFSAR figures. The licensee stated that the proposed UFSAR text is very similar to the text that was included in the AP600 DCD specifically to address shear reinforcement provisions in the nuclear island (NI) basemat. The text being modified and added is designated as Tier 2* information. UFSAR Tier 2 Figure 3.8.5-3 (Sheet 7 of 7) and Tier 2* Figure 3H.5-3, which show the basemat shear reinforcement design with a 24-inch spacing, are not changed.

2.0 REGULATORY EVALUATION

Under the current licensing basis, the basemat and NI structures are required to comply with the provisions of ACI 349-01 and supplementary requirements included in the VCSNS UFSAR Section 3.8. The proposed UFSAR Tier 2* changes are necessary to ensure consistency with both ACI 349-01 and these other supplementary UFSAR requirements.

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. The proposed amendment request involves departures to Tier 2* information. Therefore, NRC approval is required before making the Tier 2* departures addressed in this LAR. The NRC staff considered the following regulatory requirements in reviewing the licensee's 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.

10 CFR Part 50, Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," requires nuclear power plants to be designed so that, if the safe-shutdown earthquake (SSE) ground motion occurs, certain structures, systems, and components will remain functional and within applicable stress, strain, and deformation limits. The required safety functions of structures, systems, and components must be assured during and after the vibratory ground motion associated with the SSE ground motion through design, testing, or qualification methods.

3.0 TECHNICAL EVALUATION

3.1 Nuclear Island Basemat Evaluation

To perform the technical evaluation, the NRC staff considered UFSAR Sections 3.7, "Seismic Design," and 3.8, "Design of Category I Structures." The staff also examined the 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 "Final Safety Evaluation Report for the Virgil C. Summer Nuclear Station (VCSNS) Units 2 and 3 Combined License Application" (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 license amendment request (LAR) to evaluate the impact of the requested UFSAR changes on the safety of the NI foundations and structures to be constructed on the VCSNS site.

In the LAR, the licensee proposes to depart from the plant-specific DCD Tier 2* information by revising the third paragraph in UFSAR Subsection 3.8.5.5 to remove the direct reference to ACI 349-01, Subsection 11.8.3, pertaining to deep flexural members and replace it with supplemental provisions for maximum spacing of the shear reinforcement in the basemat below the auxiliary building. In particular, the licensee proposed to clarify the basemat maximum vertical reinforcement spacing requirements as d/2 (per Section 11.5.4.1) instead of d/5 (per ACI 349-01, Section 11.8.9) consistent with the design of non-prestressed two-way slabs.

In the LAR, the licensee stated that the provisions for the maximum spacing of the shear reinforcement are modified to be consistent with the basemat design description included as Tier 2 and Tier 2* UFSAR information. UFSAR Tier 2 Figure 3.8.5-3 (sheet 7 of 7) and Tier 2* Figure 3H.5-3, which show the basemat shear reinforcement design with a 24-inch maximum spacing, are not changed.

The licensee proposed to revise UFSAR Subsection 3.8.5.5 to state:

[The basemat below the auxiliary building is designed for shear in accordance with the following supplemental provisions which are based on requirements for continuous deep flexural members in ACI 349-01. As permitted by paragraph 11.5.5.1 of ACI 349-01, shear reinforcement is not provided when the factored shear force, V_u, is less than one half of the shear strength provided by the concrete, φV_c.

- *The design for shear is based on 11.1 through 11.5 of ACI 349-01 except that the critical section measured from the face of the support is taken at a distance of 0.15 l_n.*
- *Shear strength, V_n, is not taken greater than $8\sqrt{f_c'}\, b_w\, d$ when l_n/d is less than 2.*
  -When l_n/d is between 2 and 5, $V_n = 2/3\ (10 + l_n/d)\ \sqrt{f_c'}\, b_w d$
- *Minimum vertical shear reinforcement is provided in each bay. The area of vertical shear reinforcement, A_v, is not less than $0.0015\ b_w s$*
  - Spacing of shear reinforcement, s, based on provisions in Paragraph 11.5.4.1 does not exceed d/2, or 24 in.
- *Shear reinforcement required at the critical section is used throughout the span.*

*The terms φ, d, l_n, V_c, A_v, b_w, s, and f_c' are defined in ACI-349.]**

In the LAR, the licensee stated that the basemat design, with the proposed clarification of shear reinforcement requirements, remains in compliance with ACI 349-01 requirements for a foundation, including the requirements in Chapter 12 and 21 associated with seismic design and design of two-way slabs. The amended text of the UFSAR will remain Tier 2*. The staff's technical evaluation of the UFSAR Section 3.8 changes is summarized below.

Definition of Critical Section

In UFSAR Section 3.8.5.5, the licensee proposed to add a supplemental provision to Tier 2* information which states,

"The design for shear is based on Sections 11.1 through 11.5 of ACI 349-01 except that the critical section measured from the face of the support is taken at a distance of 0.15 l_n."

In LAR Section 3, the licensee stated that for a two-way slab the critical section is calculated at a distance of d, which, in the case of the basemat, would lead to a smaller shear reinforcement requirement than if the critical section were calculated at a distance 0.15 l_n. The distance "l_n" is defined in ACI 349-01 as the unsupported span length measured from the face of the supports. The licensee stated that this supplemental provision is conservative because it leads to a design that has more shear reinforcement than is required for a two-way slab.

Staff reviewed ACI 349-01, Section 11.1.3.1, and finds that for a reinforced concrete member designed as a two-way slab, the critical section is defined at a distance "d" from the face of the support, where "d" is defined as the distance from the extreme compression fiber to centroid of tension reinforcement of the cross-section. Staff also reviewed ACI 349-01 Section 11.8.5, "Deep Beam Provisions," which are applicable to flexural members with ratio of clear span versus depth (l_n/d) between 2 and 5. Section 11.8.5 defines the critical section to be located at a distance of 0.15 l_n from the support for a uniformly loaded deep beam. The staff calculated that for the basemat critical sections, the proposed critical section location results in conservative shear demands as compared to the shear demands which would otherwise be acceptable under ACI 349-01 for a basemat designed as a two-way slab. On this basis, staff finds that the computed critical section demands for shear design using ACI 349-01 Section 11.8.5 deep beam provisions is conservative for the AP1000 basemat critical sections designed as a two-way slab.

Staff review finds that the above requested revision to UFSAR Subsection 3.8.5.5 is in conformance with ACI 349-01 provisions, is conservative for the AP1000 basemat critical section designed as a two-way slab, and is therefore acceptable.

Maximum Shear Strength

In UFSAR Section 3.8.5.5, the licensee proposed to add a supplemental Tier 2* provision which states,

"Shear strength, V_n, is not taken greater than $8\sqrt{f_c'}\, b_w d$ when l_n/d is less than 2. When l_n/d is between 2 and 5, $V_n = 2/3\ (10 + l_n/d)\ \sqrt{f_c'}\, b_w d$"

In the LAR, Section 3, the licensee stated that this provision limits the shear strength that can be credited to the basemat cross-section regardless of the amount of reinforcement that is provided. The licensee contends that this supplemental provision is more restrictive than the limits that would apply to a two-way slab (Section 11.5.6.8).

Staff reviewed ACI 349-01, Section 11.5.6.8, and finds that for a reinforced concrete member designed as a two-way slab, the shear strength carried by steel reinforcement is limited to $8\sqrt{f_c'}\, b_w d$. Section 11.3.1 specifies that the shear strength provided by concrete is $2\sqrt{f_c'}\, b_w d$ (for shear and flexure). Thus, the combined maximum shear strength (steel plus concrete) permitted by the code for a two-way slab is $10\sqrt{f_c'}\, b_w d$.

Using the licensee's proposed shear strength provision, staff calculated that the maximum allowable shear strength for the basemat critical sections would be less than $10\sqrt{f_c'}\, b_w d$. Based on this comparison, staff finds the licensee's use of the deep beam provisions for the design of the AP1000 basemat to be conservative. Hence, the above supplemental provision for limiting shear strength is more restrictive than the limits specified for nominal shear strength (V_n) for two-way slabs in ACI 349-01, Subsection 11.5.6.8.

The staff finds that the above revision to UFSAR Subsection 3.8.5.5 is in conformance with ACI 349-01, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

Minimum Vertical Reinforcement

In UFSAR Section 3.8.5.5, the licensee proposed to add a supplemental Tier 2* provision which states,

"Minimum vertical shear reinforcement is provided in each bay. The area of vertical shear reinforcement, A_v, is not less than $0.0015\, b_w\, s$. Spacing of shear reinforcement, s, based on provisions in Paragraph 11.5.4.1 does not exceed d/2, nor 24 in."

In LAR Section 3, the licensee stated that, for a two-way slab, the reinforcement required is based on forces imposed on the structural sections and on the calculated demands. As such, under the current UFSAR provisions, there could be some sections of the basemat where no shear reinforcement would be required. The licensee stated that the proposed supplemental provision is conservative because it assures that the basemat has shear reinforcement in all locations, including those sections where demand is low.

Staff reviewed ACI 349-01, Section 11.5.5, pertaining to minimum shear reinforcement and finds that for a two-way slab, that minimum shear reinforcement would not be required if the factored shear demand were less than one-half the shear strength provided by the concrete. Staff review of the proposed supplemental provision finds that the proposed provision commits the licensee to provide minimum shear reinforcement regardless of shear demands, which is conservative for the basemat designed as a two-way slab.

Staff also performed a review of the proposed UFSAR provision for the maximum spacing of shear reinforcement (i.e., maximum of d/2 or 24 inches), and finds the supplemental provision to be consistent with ACI 349-01, Section 11.5.4 provisions for the design of two-way slabs. Since the AP1000 basemat is analyzed, designed, and detailed as a two-way slab, the maximum shear reinforcement spacing of d/2 or 24 inches is appropriate for the detailing of the basemat shear reinforcement. Accordingly, the staff finds that the above revision to UFSAR Subsection 3.8.5.5 is in conformance with ACI 349-01, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

Critical Section Shear Reinforcement Used Throughout the Span

In UFSAR Section 3.8.5.5, the licensee proposed to add a supplemental Tier 2* provision which states,

"Shear reinforcement required at the critical section is used throughout the span."

In LAR Section 3, the licensee states that for a two-way slab the reinforcement required is based on the demands on the structural sections. This could result in mat cross-sections with variable shear reinforcement spacing and potentially no shear reinforcement in low demand locations. The licensee stated that this supplemental provision is conservative because it imposes the reinforcement calculated at the critical section, which is the largest amount required, throughout the rest of the mat. This leads to a design that has more shear reinforcement than is required by the force demands.

Staff review of the licensee's proposed supplemental provision finds that providing the shear reinforcement that is calculated at the critical section throughout the basemat to be conservative. Staff notes that based on ACI 349-01, shear reinforcement for a two-way slab under uniform pressure loads could be designed in proportion to the factored shear demands, which linearly decrease with distance from the support. Designing the basemat using the same shear reinforcement throughout the span will result in a conservative design. The staff finds that the above revision to UFSAR Subsection 3.8.5.5 is in conformance with ACI 349-01, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

Staff finds that the above supplemental requirements added to UFSAR Subsection 3.8.5.5 pertaining to the basemat shear reinforcement are conservative because they add additional shear reinforcement beyond that required for a two-way slab and they result in a conservative basemat design that is consistent with ACI 349-01 requirements. The changes do not impact seismic design assumptions as they do not affect stiffness assumptions described in UFSAR Section 3.7.2.

The design of the AP1000 basemat is consistent with the spacing shown in the UFASR Figures 3H.5-3 and 3.8.5-3 (Sheet 7 of 7). Therefore, the requested UFSAR changes do not result in physical design changes to the AP1000 basemat design.

3.2 Conclusions

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

1. The supplemental provision pertaining to the definition of critical section is in conformance with ACI 349-01 provisions, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

2. The supplemental provision pertaining to maximum shear strength is in conformance with ACI 349-01, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

3. The supplemental provision pertaining to minimum vertical reinforcement is in conformance with ACI 349-01 provisions, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

4. The supplemental provision pertaining to the critical section shear reinforcement used throughout the span is in conformance with ACI 349-01, is conservative for a basemat designed as a two-way slab, and is therefore acceptable.

5. The proposed supplement provisions do not affect the seismic analysis assumptions described in UFSAR Section 3.7.2

For the reasons specified above, the staff finds the proposed amendment and the supporting analysis provided to be conservative and to not affect the analysis results and related conclusions presented in the UFSAR related to basemat design and seismic analysis. Based on these findings, the NRC staff concludes that there is reasonable assurance that the requirements of GDC 1, GDC 2, and GDC 4 for 10 CFR 50 Appendix A, 10 CFR 50 Appendix S, and Appendix D to 10 CFR Part 52 will continue to be met. Therefore, the staff finds the proposed change acceptable.

4.0 FINAL NO SIGNIFICANT HAZARDS CONSIDERATION

The NRC's regulations in 10 CFR 50.92, "Issuance of Amendment," state that the NRC may make a final determination that a license amendment involves no significant hazards consideration if operation of the facility, in accordance with the amendment, would not: (1) involve a significant increase in the probability or consequences of an accident previously evaluated, or (2) create the possibility of a new or different kind of accident from any accident previously evaluated, or (3) involve a significant reduction in a margin of safety. The Commission previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (78 FR 5511, dated January 25, 2013).

As required by 10 CFR 50.91(a), the NRC staff presents an evaluation of the issue of no significant hazards consideration as follows:

Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No.

The design function of the basemat is to provide the interface between the nuclear island structures and the supporting soil or rock. The basemat transfers the load of nuclear island structures to the supporting soil or rock and transmits seismic motions from the supporting soil or rock to the nuclear island.

The clarification of the requirements for shear reinforcement spacing in the AP1000 basemat does not have an adverse impact on the response of the basemat and nuclear island structures to safe shutdown earthquake ground motions or loads due to anticipated transients or postulated accident conditions. The clarification of the requirements for shear reinforcement spacing in the AP1000 basemat does not impact the support, design, or operation of mechanical and fluid systems. There is no change to plant systems or the response of systems to postulated accident conditions. There is no change to the predicted radioactive releases due to normal operation or postulated accident conditions. The plant response to previously evaluated accidents or external

events is not adversely affected, nor does the change described create any new accident precursors. Therefore, there is no significant increase in the probability or consequences of an accident previously evaluated.

Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

The proposed change is to clarify the requirements for shear reinforcement spacing in the nuclear island basemat. The clarification of the requirements for shear reinforcement spacing in the nuclear island basemat does not change the design of the basemat or nuclear island structures. The clarification of the requirements for shear reinforcement spacing in the nuclear island basemat does not change the design function, support, design, or operation of mechanical and fluid systems. The clarification of the requirements for shear reinforcement spacing in the nuclear island basemat does not result in a new failure mechanism for the basemat or new accident precursors. As a result, the design function of the basemat is not adversely affected by the proposed change. Therefore, the proposed change will not create the possibility of a new or different kind of accident from any accident previously evaluated.

Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No.

No safety analysis or design basis acceptance limit/criterion is challenged or exceeded by the proposed changes, thus, no margin of safety is reduced. Therefore, the proposed amendment does not involve a significant reduction in a margin of safety.

Based on the above evaluation, the NRC staff concludes that the three standards of 10 CFR 50.92(c) are satisfied. Therefore, the NRC staff has made a final determination that no significant hazards consideration is involved for the proposed amendment and that the amendment should be issued consistent with 10 CFR 50.92, “Issuance of Amendment.”

5.0 STATE CONSULTATION

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

6.0 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, and that there is no significant increase in individual or cumulative occupational radiation exposure. As described above in Section 4.0 of this safety evaluation, the NRC staff has found that the amendment involves no significant hazards consideration.

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.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that 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.

8.0 REFERENCES

1. Request for License Amendment (LAR 13-01) Basemat Shear Reinforcement Design Spacing Requirements, letter from South Carolina Electric and Gas Company (SCE&G) dated January 15, 2013 (ML13017A082)

2. Virgil C. Summer Nuclear Station (VCSNS) Updated Final Safety Analysis Report (UFSAR), Revision 0, dated July 3, 2012 (ML122010130)

3. AP1000 DCD Revision 19, June 13, 2011 (ML11171A500)

4. VCSNS Final Safety Evaluation Report (FSER) dated August 17, 2011 (ML110450305)

5. Final Safety Evaluation Report Related to Certification of the AP1000 Standard Plant Design, NUREG 1793, Supplement 2, dated August 5, 2011 (ML112061231)

6. NUREG-800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (ML070810350)

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