

SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS
RELATED TO AMENDMENT NO. 2 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 18, 2013, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13022A418), South Carolina Electric & Gas Company (SCE&G/Licensee) requested that the U.S. Nuclear Regulatory Commission (NRC/Commission) 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 changes would depart from plant-specific Design Control Document (DCD) Tier 2* and associated Tier 2 material incorporated into the Updated Final Safety Analysis Report (UFSAR) by revising the structural analysis code requirements to provide alternative requirements for development of shear reinforcement bars within the nuclear island basemat concrete.

The proposed changes revise the code provisions for development of basemat shear reinforcement in the licensing basis from the American Concrete Institute (ACI) code ACI 349-01 Appendix B to ACI 318-11, Section 12.6. The licensee stated that the use of ACI 318 criteria for headed reinforcement would result in longer shear ties and thicker concrete in areas below the elevator pits and a sump in the nuclear island basemat. The licensee also stated that the thicker concrete is accomplished by raising the floor of the elevator pits and sump in the nuclear island basemat resulting in a minor reduction in volume of the sump. The provisions for concrete cover over the reinforcement bars are also being changed. However, the licensee indicated that the conformance of the seismic Category I structures to the balance of the ACI 349 requirements, as supplemented in the UFSAR, is not changed.

2.0 REGULATORY EVALUATION

The commitment that the basemat and nuclear island structures will comply with the provisions of ACI 349-01 is included as Tier2* information in 10 CFR Part 52, Appendix D, Section VIII.B.6.c(4). This commitment and supplementary information are included in UFSAR Sections 3.7 and 3.8. The proposed changes revise the code provisions for development of basemat shear reinforcement in the licensing basis from ACI 349-01 Appendix B to ACI 318-11, Section 12.6.

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 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.

3.0 TECHNICAL EVALUATION

To perform the technical evaluation, the NRC staff considered UFSAR Section 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 nuclear island 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 several UFSAR Chapter 3.8, subsections to (1) provide alternative provisions to ACI 349-01, Appendix B for anchoring headed shear reinforcement, (2) increase slab thickness in basemat sump and elevator pit areas, and (3) revise provisions for concrete cover over reinforcement bars. The staff's technical evaluation of these design changes is summarized below.

Alternative ACI Code Provisions for Development of Headed Anchors

In the LAR, the licensee proposes to revise the provisions for development of basemat shear reinforcement in the licensing basis from ACI 349-01 Appendix B to ACI 318-11, Section 12.6, "Development of Headed and Mechanically Anchored Deformed Bars in Tension." The proposed changes affect various statements in UFSAR Subsections 3.8.3, 3.8.4, 3.8.5, and 3.8.7. In LAR, Section 3, the licensee stated that the state-of-the-art requirements related to headed bars development in ACI 318-11 are more prescriptive than the ACI 349 Appendix B requirements. The licensee further stated that ACI 318 is a consensus standard for design of reinforced concrete structures whose use is limited in this application to the development of headed shear reinforcement in the basemat. In the LAR, the licensee also stated that the design of shear reinforcement sizing, spacing, and detailing continues to be governed by ACI 349-01, including Chapter 21.

The staff performed a review of the licensee's proposed UFSAR changes and of the ACI 318-11, Section 12.6 provisions that define the development length in tension for headed deformed bars. ACI 318, Section 12.6 provisions contain an empirical equation for development length, which is a function of steel yield strength, concrete compressive strength, and tie-bar diameter.

Applicability of ACI 318-11

Staff review of ACI 318-11, Section 12.6, focused on the applicability of the ACI 318 provision to the design of the AP1000 basemat and the consistency of that provision with the intent of the provisions of ACI 349-01, including Appendix B and Chapter 21. Staff notes that the ACI 349-01 code commentary states that the provisions of ACI 349-01 are based on those of ACI 318-95. The staff's review found that ACI 318-95 and the later code version (ACI 318-11) have similar approaches for the design and detailing of reinforced concrete structures to ensure adequate strength, stiffness, and ductility under seismic demands. As such, both codes have similar provisions for anchorage and development of steel reinforcement. On this basis, the staff finds that the development and anchorage provisions of ACI 318-11 are consistent with those of ACI 349-01.

Seismic Detailing in ACI 349, Chapter 21

In LAR Section 3, the licensee stated that the narrow application of ACI 318-11, Section 12.6, provides for adequate development of the headed shear reinforcement to provide ductile behavior consistent with ACI 349-01, Chapter 21. UFSAR Subsection 3.8.4.4.1 contains a Tier 2* commitment stating that the ductility criteria of ACI 349-01, Chapter 21, are applied in detailing and anchoring of the reinforcing steel.

Staff performed a review of the proposed alternative ACI 318-11 provision to assess its consistency with ACI 349-01, Chapter 21 detailing provisions. To this end, staff reviewed the scope of ACI 318-11 Chapter 21, "Earthquake-Resistant Structures," and found the chapter to provide provisions for design and construction of reinforced concrete members of structures for which the design forces, related to earthquake motions, have been determined on the basis of energy dissipation in the nonlinear range of response. Further, the staff found that the detailing provisions in ACI 318 Chapter 21 are intended to ensure structures have a high level of integrity and ability to undergo the required nonlinear deformations necessary to dissipate earthquake energy.

The staff's review of the scope of ACI 349-01 Chapter 21 commentary found that although the design of nuclear power plant structures does not rely on energy dissipation through nonlinear response, the provisions in ACI 349, Chapter 21, are intended to ensure a high level of confidence in the retention of structural integrity for the design basis safe shutdown earthquake (SSE) loads. The commentary to ACI 349, Chapter 21 (R21.2) states that ACI 318, Chapter 21, provisions were adopted in ACI 349, Chapter 21, on the basis that they provide assurance that structural integrity is maintained in the unlikely event of an earthquake beyond the design basis SSE or other unforeseen circumstances. As such, the staff finds that the seismic detailing provisions, specifically as they relate to rebar development, are consistent in both codes.

ACI 318-11, Chapter 21, provisions state that the design of anchorage must satisfy Chapters 1 through 19 in addition to Section 21.1.8, "Anchoring to Concrete." Staff performed a review of the ACI 318, Section 21.1.8, provisions and found that there are no modifications to the Section 12.6 provision, and therefore finds that ACI 318, Section 12.6, satisfies the ACI 318 Chapter 21 anchorage provisions.

Based on the above findings, staff finds that the ACI 318-11, Section 12.6, provisions satisfy the VCSNS UFSAR, Subsection 3.8.4.4.1, commitment to design the basemat in accordance with ACI 349-01, Chapter 21.

ASTM A970 Material Specification

The provisions of ACI 318-11, Section 12.6, require use of reinforcing bars that satisfy Class HA testing specified in ASTM A970-09, "Standard Specification for Headed Steel Bars for Concrete Reinforcement." ASTM A970 is a material specification for headed reinforcement bars which provides performance requirements to ensure the steel bar head develop the minimum specified tensile strength of the bar. VCSNS UFSAR, Subsection 3.8.4.6.1.2, contains Tier 2* information describing that the A970 standard is to be used for design of mechanical anchorage. However, the version of the ASTM standard is not specified. In this LAR, the licensee proposes to revise the relevant UFSAR sections to reference ASTM A970-2009. Namely, the licensee proposes to revise UFSAR Section 3.8.7, "References," and Table 3.8.4-6 for identification of basic structural materials to reference ASTM A970-2009.

The staff finds that the licensee's proposed UFSAR changes pertaining to A970 acceptable because the A970-2009 standard provides performance requirements to ensure the steel bar heads will develop the tensile capacity of the anchored bar and is consistent with the provisions of ACI 318-11, Section 12.6.

Because the proposed alternative code provision (a) is derived from an internationally recognized consensus standard for reinforced concrete structures, (b) represents codification of the state-of-the art knowledge on headed anchorage behavior, (c) is derived from anchor design requirements similar to that of ACI 349 Appendix B, (d) satisfies ACI 349, Chapter 21, anchorage provisions, and (e) is used in conjunction with ASTM A970-2009 which is consistent with ACI 318-11, the staff finds the use of ACI 318-11, Section 12.6 provisions for the development of head-bar reinforcement in the basemat acceptable.

Increase in Sump and Elevator Slab Thickness

In the LAR, the licensee proposes to increase the thickness of the concrete in areas below the elevator pits and the sump in the nuclear island basemat from 1.5 feet to 2.0 feet to accommodate the increased length of the shear ties as required by the ACI 318-11,

Section 12.6 provisions. UFSAR Figure 3.8.4-4 (sheet 1) will be revised to remove the elevation of the elevator pit from the figure. Similarly, UFSAR Figure 3.8.5-3 (sheets 3 and 4) will be revised to reflect the 6-inch increase in slab thickness.

In the LAR, Section 3, the licensee states that the small increase in thickness of concrete in the nuclear island basemat below the elevator pits and sump to accommodate a longer shear reinforcement development length, does not change the response of the basemat and nuclear island structures to seismic motions and loads. The seismic response spectra used for analysis of structures, systems, and components are not changed.

Staff reviewed the UFSAR Figure 3.8.5-3 (sheets 3 and 4) and finds that the relative sizes of the sump and elevator pit areas (~450 square feet) are small in comparison to the nuclear island basemat (~32,000 square feet). Such a small addition to the mass of the nuclear island basemat will have a negligible impact on the seismic response of the basemat and the nuclear island structures. The staff notes that UFSAR Subsection 3.8.4 states that the design, of the sump and elevator pit areas, will continue to be in accordance with ACI 349-01.

Based on the licensee's continued commitment to design the sump and elevator pit areas in accordance with ACI 349-01 code provisions, the relatively minor increase in mass in the basemat, and the negligible impact to seismic response, the staff finds the proposed design change acceptable.

Minimum Concrete Cover

In the LAR, the licensee proposes to revise the UFSAR Subsection 3.8.4.6.1.2 commitment for 2 inches of minimum concrete cover for seismic Category I structures that are located below grade elevation to conform to the ACI 349-01, Section 7.7, provisions for concrete exposed to earth or weather.

This UFSAR subsection states that a waterproofing system, described in UFSAR Subsection 3.4.1.1.1, in conjunction with the ACI 349-01 code provisions for concrete cover for exposure to earth or weather, and provides sufficient protection for the reinforcing steel.

Staff reviewed ACI 349-01, Section 7.7, and finds that the provisions require a minimum of 2 inches of cover for concrete exposed to earth or weather for No. 6 through No. 18 reinforcing bars. No. 5 reinforcing bars and smaller will require 1.5 inches of minimum concrete cover. On the basis that the UFSAR change is consistent with the ACI 349-01, Section 7.7 provisions, which continues to provide reasonable assurance of adequate protection for the rebar, the staff finds the change acceptable.

3.2 Conclusions

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

- The proposed alternative code provision, namely ACI 318-11, Section 12.6, is derived from an internationally recognized consensus standard for reinforced concrete structures and represents the state-of-the art in knowledge on headed-rebar anchorage behavior.
- The proposed alternative code provision, ACI 318, Section 12.6, is derived from rebar anchor design requirements similar to those of ACI 349 Appendix B, satisfies ACI 318, Chapter 21 anchorage provisions, and is therefore acceptable.

- The proposed change to reference ASTM A970-2009 provides requirements for ensuring headed reinforcement will achieve full tensile strength and is consistent with ACI 318-11, Section 12.6, and is therefore acceptable.
- The design change to the sump and elevator pit areas result in a relatively minor increase in mass in the basemat and do not impact the seismic design analysis assumptions described in UFSAR Section 3.7.
- The licensee's proposed design change to the sump and elevator pit slabs will be performed in accordance with ACI 349-01 code provisions, and is therefore acceptable.
- The UFSAR change to concrete cover is consistent with ACI 349, Section 7.7 provisions for exposure to earth or weather and is therefore acceptable.

For the reasons specified above, the staff concludes that the proposed UFSAR amendments to revise the requirements for development of basemat shear reinforcement in the licensing basis from ACI 349 Appendix B to ACI 318-11, Section 12.6 are acceptable. Similarly, the staff concludes that the proposed UFSAR amendments to increase the sump and elevator pit slab thicknesses, and to reference ACI 349-01 provisions for minimum concrete cover are acceptable. The changes will not affect the analysis results and related conclusions presented in the AP1000 DCD and UFSAR related to basemat design and seismic analysis. Consequently, the NRC staff concludes that there is reasonable assurance that the requirements of GDC1, GDC 2, and GDC 4 of Appendix A to 10 CFR Part 50, Appendix S to 10 CFR Part 50, and Appendix D (Section VIII B6) to 10 CFR Part 52 will continue to be met. Therefore, the staff concludes the proposed changes are 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 6145, dated January 29, 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 nuclear island 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. The basemat transmits seismic motions from the supporting soil or rock to the nuclear island.

The change of the provisions for anchoring basemat shear reinforcement 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 change of the provisions for anchoring basemat shear reinforcement 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, the proposed amendment does not involve a 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 provide the provisions for anchoring nuclear island basemat shear reinforcement. The change of the provisions for anchoring basemat shear reinforcement does not change the design of the basemat or nuclear island structures except to a limited extent in the concrete below the elevator pits and auxiliary building sump. The change of the provisions for anchoring basemat shear reinforcement does not change the design function, support, design, or operation of mechanical and fluid systems. It also 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 amendment does 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 in 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 staff 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– Basemat Shear Reinforcement Design Details (LAR-13-02), letter from South Carolina Electric and Gas Company (SCE&G) dated January 18, 2013 (ML13022A418)
2. Virgil C. Summer Nuclear Station (VCSNS) Updated Final Safety Analysis Report (UFSAR), Revision 0, dated July 3, 2012 (ML12201A130)
3. AP1000 DCD Revision 19, June 13, 2012 (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. American Concrete Institute (ACI), "Building Code Requirements for Nuclear Safety Related Structures," ACI-349-01
7. American Concrete Institute (ACI), "Building Code Requirements for Structural Concrete," ACI 318-11

8. American Concrete Institute (ACI), "Building Code Requirements for Structural Concrete," ACI 318-95
9. ASTM A 970-2009, "Standard Specification for Headed Steel Bars for Concrete Reinforcement"