

SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS  
RELATED TO AMENDMENT NO. 5 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 March 26, 2013, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13087A304), South Carolina Electric & Gas (SCE&G/licensee) requested that the U.S. Nuclear Regulatory Commission (NRC) amend the combined licenses (COLs) for Virgil C. Summer Nuclear Station (VCSNS) Units 2 and 3, COL Numbers NPF-93 and NPF-94, respectively. The proposed changes would depart from the updated final safety analysis report (UFSAR) Tier 2\* and associated Tier 2 material incorporated into the UFSAR by revising the structural analysis requirements to provide alternative requirements for development of headed reinforcement bars (T-heads) within the nuclear island structures above the basemat elevation.

The licensee stated that the proposed changes provide alternative requirements for development of headed reinforcement in the licensing basis from the American Concrete Institute (ACI) code ACI 349 Appendix B to include ACI 318-11, Section 12.6. The proposed changes clarify the design and licensing basis for the headed reinforcement bars in locations including auxiliary building walls and walls within the containment. The associated licensing basis figures for the auxiliary building wall reinforcement are also being revised. The size and spacing of the shear reinforcement in these walls is replaced with a reference to the provided shear reinforcement. The use of shear ties with alternating 90-degree and 135-degree hooks to provide shear reinforcement in the walls in lieu of the headed reinforcement is also included as an alternative for the exterior walls below grade.

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 Tier 2\* information in 10 CFR 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 acceptance criteria for development of

headed shear and tension reinforcement above the basemat 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 Combined License Application," (ADAMS Accession No. ML110450305) documenting the staff's technical evaluation of those aspects of the AP1000 Design Control Document (DCD) and the VCSNS COL application, respectively. The safety evaluation related to the License Amendment Request (LAR) 13-004 relating to the design of headed reinforcement in the nuclear island (NI) basemat was also considered. The staff reviewed the proposed LAR 13-11 (herein to forth referred to as the LAR), to evaluate the impact of the requested UFSAR changes on the safety of the NI structures to be constructed at the VCSNS site.

In the LAR, the licensee proposed to depart from the UFSAR Tier 2\* information by revising several UFSAR Chapter 3.8 subsections to (1) include alternative ACI 318 provisions for NI headed shear and tension reinforcement, (2) replace shear reinforcement information in relevant UFSAR critical wall section figures, (3) utilize ties with standard hooks along with headed bars (T-heads) for shear reinforcement, (4) revise a critical section figure, and (5) revise

shear reinforcement provided for critical wall sections. The licensee stated that the proposed changes do not impact the thicknesses or configurations of NI walls. The staff's technical evaluation of these design changes is summarized below.

### 3.1.1 Alternative ACI 318 Code Provisions for Headed Reinforcement

In the LAR, the licensee proposed to revise the requirements for development of the NI headed shear and tension reinforcement in the licensing basis from ACI 349-01 Appendix B to include ACI 318-11, Section 12.6, "Development of Headed and Mechanically Anchored Deformed Bars in Tension," as an alternative acceptance criteria. The proposed changes affect various statements in UFSAR Subsections 3.8.3, 3.8.4, and associated statements, tables, and figures in Appendix 3H.

The staff performed a review of the licensee's proposed UFSAR changes and of ACI 318-11, Section 12.6 provisions, which 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.

Staff's review of ACI 318-11, Section 12.6, focused on the applicability of the ACI 318 provision to the design of the AP1000 NI walls and the consistency of that provision with the intent of the provisions of ACI 349-01, including Appendix B and Chapter 21. The 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. Staff's review finds 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 concludes that the development and anchorage provisions of ACI 318-11 are consistent with those of ACI 349-01.

#### *Seismic Detailing Under ACI 349, Chapter 21*

In the LAR, the licensee stated that ACI 318-11, Section 12.6, provides for adequate development of the headed reinforcement to provide ductile behavior consistent with the requirements of 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.

The staff performed a review of the proposed alternative ACI 318-11 requirement to assess its consistency with ACI 349-01, Chapter 21 detailing requirements. To this end, the staff reviewed the scope of ACI 318-11 Chapter 21, "Earthquake-Resistant Structures," and found the chapter to provide requirements 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 requirements 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.

Staff's review of the scope of ACI 349-01 Chapter 21 commentary finds 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 staff noted that 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 requirements, 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 the requirements of Section 21.1.8, "Anchoring to Concrete." The staff performed a review of Section 21.1.8 provisions and finds there are no modifications to the Section 12.6 provision, and therefore finds that 12.6 satisfies ACI 318 Chapter 21 anchorage provisions.

Based on the above findings, the staff concludes that the ACI 318-11, Section 12.6, provisions satisfy the UFSAR, Subsection 3.8.4.4.1, commitment to design the NI walls 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. 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 the LAR, the licensee stated that, based on the Issuance of License Amendment No. 2 for VCSNS Units 2 and 3, Reference 49 of the UFSAR Section 3.8 has been revised to identify the ASTM A970-09 revision as the licensing basis for specification of headed reinforcement.

Staff's Safety Evaluation (SE) of LAR No. 2 (ADAMS Accession No. ML13056A190) found that the licensee's reference to A970 was acceptable on the basis that 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.

On the basis that 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 those 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 NI walls acceptable.

#### 3.1.2 NI Wall Critical Section Shear Reinforcement Information

In the LAR, the licensee proposed to replace explicit shear reinforcement size and spacing information from UFSAR Figures 3H.5-3, 3H.5-4, 3H.5-6, and 3H.5-12 with a note referencing UFSAR Subsection 3.8.4 and respective tables in Appendix 3H. In particular, the licensee stated that the size and spacing information is replaced with a reference to the provided shear reinforcement in the specific tables associated with each wall to permit the use of either headed reinforcement or shear ties with hooks as shear reinforcement. Further, the licensee proposed

to add a note to reference UFSAR Subsection 3.8.4.4.1 for requirements for shear reinforcement. Lastly, the licensee revised Subsection 3.8.4 to incorporate the alternative acceptance criteria for the development of headed reinforcement.

Staff's review of the proposed changes to Subsection 3.8.4 finds that the licensee continues to remain committed to the reinforcement design criteria in ACI 349-01, and the use of acceptable alternative criteria for development of headed bars as stated in Section 3.1.1 of this LAR. Accordingly, staff has reasonable assurance that reinforcement should continue to meet an acceptable level of safety. On this basis, the revised UFSAR figures, the note referring to Subsection 3.8.4, and to relevant Appendix 3H tables, are found to be acceptable.

### 3.1.3 Use of Shear Ties with Standard Hooks as Shear Reinforcement

In the LAR, Enclosure 1, the licensee proposes the use of ties with standard hooks as one of the alternative to headed bars for shear reinforcement. The licensee stated that the use of shear ties with 90 and 135 degree standard hooks will meet the development requirements of ACI 349 Section 12.13.

Staff's review of ACI 349, Section 12.13, which pertains to development of web reinforcement, finds that the provisions are applicable to shear reinforcement in the NI walls. The staff also finds that the use of standard hooks is consistent with the seismic detailing provisions of Chapter 21.

Based on the above and the licensee's continued commitment to the reinforcement design criteria in ACI 349-01, the staff finds the use of ties with standard hooks as an alternative for headed bars, used as shear reinforcement of the NI walls to be acceptable.

### 3.1.4 Revision of UFSAR Figure 3H.5-6

In the LAR, the licensee provided a change to a UFSAR Figure 3H.5-6 note indicating a change from anchor to T-head and adding a note referencing UFSAR Subsection 3.8.4.4.1 for the development requirements of headed reinforcement.

After the review of UFSAR Figure 3H.5-6 changes, the staff finds the use of a T-head system in lieu of an anchor to be acceptable because both ACI 349-01 and ACI 318-11 address this system. The staff finds the figure note to be acceptable as the note references UFSAR Subsection 3.8.4.4.1, which is addressed in Section 3.1.1 of this SE. On this basis, the staff finds the proposed changes to Figure 3H.5-6 to be acceptable.

### 3.1.5 Revision of Shear Reinforcement provided in Critical Wall Sections

In the LAR, the licensee proposed changes to UFSAR Tables 3H.5-3 and 3H.5-7 to reduce the minimum provided shear reinforcement. The provided reinforcement remains greater than the required. The LAR stated that the change in provided reinforcement is needed for selecting rebar sizes that can adequately be developed in the walls while maintaining the reinforcement within code compliance. The LAR also stated that the design of the reinforcement sizing, spacing, and detailing continues to be governed by the requirements of ACI 349-01, including Chapter 21. Further, the LAR stated that the revised minimum area provided is based on providing a shear reinforcement area greater than the area required, while meeting the applicable ACI 349-01 code requirements for shear reinforcement spacing and either the

ACI 349-01 Paragraph 12.13 requirements for development of conventional shear ties or the ACI 318-11 Paragraph 12.6 requirements for development of headed deformed bars.

The staff finds that, while the LAR proposed to reduce the minimum provided shear reinforcement in the applicable NI walls, the revised design maintains margin to that required by the ACI-349 code. The proposed shear reinforcement design is based on the requirements of the ACI 349 code, and the alternative provisions for development length of Section 12.6 of the ACI 318-11 Code. On this basis, staff finds the proposed change to shear reinforcement in the applicable NI walls to be acceptable.

### 3.2 Conclusions

Based on the staff's technical evaluation, the staff finds 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 318-11, 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 use of hooked shear hook ties as a replacement for headed shear reinforcement is in conformance with ACI 349 code provisions, including those pertaining to seismic detailing (Chapter 21), and is therefore acceptable.
- The reduction of the minimum provided shear reinforcement does not affect the safety of the NI walls because the provided area is more than that required by the ACI 349 Code, and is therefore acceptable.
- Replacing wall shear reinforcement (size and spacing) with a provided shear reinforcement area (in tabular form) continues to satisfy the level-of-detail needed to describe the design of critical sections and does not relieve the requirement to perform detailed design in accordance with ACI 349 code provisions, and is therefore acceptable.

For the reasons specified above, the staff finds the proposed UFSAR amendments to include ACI 318 Section 12.6 as alternative requirements to ACI 349-01 Appendix B for headed shear and tension reinforcement, acceptable. Similarly, the staff finds the proposed UFSAR amendments to replace size and spacing from licensing basis figures with a reference to Subsection 3.8.4 and Tables 3H.5-3 and 3H.5-7, and the reduced minimum shear reinforcement area in these tables, acceptable. Also, the staff finds the use of shear hook ties along with headed bars, acceptable. The changes will not affect the analysis results and related conclusions presented in the AP1000 DCD and the VCSNS UFSAR related to NI wall 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 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 22563, dated April 16, 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 functions of the nuclear island structures are to provide support, protection, and separation for the seismic Category I mechanical and electrical equipment located in the nuclear island. The nuclear island structures are structurally designed to meet seismic Category I requirements as defined in Regulatory Guide 1.29.

The change of the requirements for anchoring headed reinforcement does not have an adverse impact on the response of the nuclear island structures to safe shutdown earthquake ground motions or loads due to anticipated transients or postulated accident conditions. The change of the requirements for anchoring headed 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 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 requirements for anchoring nuclear island headed reinforcement. The proposed change does not change the design of the nuclear island structures except to a limited extent to redistribute the shear reinforcement in the walls of the nuclear island. The proposed change does not impact the support, design, or operation of mechanical or fluid systems. The proposed change does not result in a new failure mechanism for the nuclear island structures or new accident precursors. As a result, the design functions of the nuclear island structures and the seismic Category I mechanical and electrical equipment located in the nuclear island are 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 change, thus, no margin of safety is reduced. The limited application of alternative criteria for headed reinforcement does not reduce the margin of safety. 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 in Section 3.0, 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. Therefore, the staff finds the changes proposed in this license amendment request acceptable.

## 8.0 REFERENCES

1. Request for License Amendment – Nuclear Island Walls Reinforcement Criteria (LAR 13-011), letter from South Carolina Electric & Gas, dated March 26, 2013 (ADAMS Accession No. ML13087A304).
2. Issuance of License Amendment No. 2 for Virgil C. Summer Nuclear Station Units 2 and 3: “Basemat Shear Reinforcement Design Details,” dated March 1, 2013 (ADAMS Accession No. ML13056A183).
3. Virgil C. Summer Nuclear Station, Updated Final Safety Analysis Report, Revision 0, dated July 3, 2012 (ADAMS Accession No. ML12201A130)
4. AP1000 Design Control Document, Revision 19, dated June 13, 2012 (ADAMS Accession No. ML11171A087)
5. Virgil C. Summer Nuclear Station, Final Safety Evaluation Report, dated August 17, 2011 (ADAMS Accession No. ML110450305)
6. Final Safety Evaluation Report Related to Certification of the AP1000 Standard Plant Design, NUREG-1793, August 5, 2011 (ADAMS Accession No. ML112061231).
7. American Concrete Institute (ACI), “Building Code Requirements for Nuclear Safety Related Structures,” ACI-349-01.
8. American Concrete Institute (ACI), “Building Code Requirements for Structural Concrete,” ACI 318-11.
9. American Concrete Institute (ACI), “Building Code Requirements for Structural Concrete,” ACI 318-95.