



**UNITED STATES
NUCLEAR REGULATORY COMMISSION**
REGION II
245 PEACHTREE CENTER AVENUE NE, SUITE 1200
ATLANTA, GEORGIA 30303-1257

March 26, 2013

EA-13-009

South Carolina Electric and Gas
ATTN: Mr. Ronald A. Jones
Vice President, New Nuclear Operations
P.O. Box 88 (Mail Code P40)
Jenkinsville, SC 29065-0088

SUBJECT: SOUTH CAROLINA ELECTRIC AND GAS (SCE&G), V.C. SUMMER NUCLEAR STATION UNIT 2 – U.S. NUCLEAR REGULATORY COMMISSION ITAAC INSPECTION, INSPECTION REPORT NO. 05200027/2013008; PRELIMINARY WHITE FINDING

Dear Mr. Jones:

On February 12, 2013, the U.S. Nuclear Regulatory Commission (NRC) completed an inspection at your V.C. Summer Nuclear Station, Unit 2. The enclosed inspection report documents the inspection results that were discussed on December 21, 2012, and February 12, 2013, with you, Mr. J. Archie, Sr. Vice President, Nuclear Operations, members of your staff, and representatives of the consortium.

The inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations, and with the conditions of your license. The inspectors reviewed selected calculations, drawings, and other relevant information.

The enclosed inspection report discusses a finding and associated apparent violation (AV) of Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix B, Criterion III, "Design Control," regarding SCE&G's failure to assure that applicable regulatory requirements were correctly translated into design specifications, drawings, procedures, and instructions. This finding has preliminarily been determined to be a White finding with low to moderate safety significance that may require additional NRC inspections. As described in the enclosed report, the anchorage and spacing of the headed shear reinforcement in multiple structural components of the nuclear island (NI), as detailed in the final design documents, did not comply with the provisions of the "Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01)," as required by the Updated Final Safety Analysis Report (UFSAR). This finding did not present an immediate safety concern because the project is still in construction. Nonetheless, this nonconformance would likely have led to a latent construction defect that could have had safety consequences after transitioning to operation of the facility as: the designs of the affected components were complete, associated drawings released for

R. Jones

construction, and there were not any planned quality assurance reviews of a nature that could reasonably have been expected to identify and preclude these deficiencies from being constructed. This finding was assessed based on the best available information, using the applicable construction Significance Determination Process (SDP). The final resolution of this finding will be conveyed in separate correspondence.

The basis for the NRC's preliminary significance determination for this issue is that without adequate spacing and anchorage of the headed reinforcement, the structural components that rely upon this system may be subject to brittle failure at a demand less than that required by the design basis loads. Your staff provided calculations and other information on December 17, 2012, to support your assessment that the system, as specified, would be adequately anchored. The design method used in these calculations, however, appears to be insufficient for predicting behavior of the system, and as a result, may yield non-conservative results. Absent adequate technical justification for the specified system - based on acceptance criteria generally recognized to be reliable for predicting behavior and demonstrating adequacy, such as conformance with a proven comprehensive design model applicable to headed shear reinforcement, or reliance on relevant testing data bounding all configurations - it is not possible to conclude with reasonable assurance that the structural components that utilize headed shear reinforcement would have satisfactorily performed their intended design functions.

The AV associated with this finding is being considered for escalated Enforcement Action (EA) in accordance with the Enforcement Policy, which can be found on the NRC's Web site at <http://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html>.

In accordance with NRC Inspection Manual Chapter (IMC) 2519P, "Construction Significance Determination Process - Pilot," we intend to complete our evaluation using the best available information and issue our final determination of safety significance within 90 days of the date of this letter. The significance determination process encourages an open dialogue between the NRC staff and the licensee; however, the dialogue should not impact the timeliness of the staff's final determination.

Before we make a final decision on this matter, we are providing you with an opportunity to:

- (1) attend a Regulatory Conference where you can present to the NRC your perspective on the facts and assumptions the NRC used to arrive at the finding, and assess its significance, or
- (2) submit your position on the finding to the NRC in writing. If you request a Regulatory Conference, it should be held within 30 days of the receipt of this letter, and we encourage you to submit supporting documentation at least one week prior to the conference in an effort to make the conference more efficient and effective. If a Regulatory Conference is held, it will be open for public observation. If you decide to submit only a written response, such submittal should be sent to the NRC within 30 days of your receipt of this letter. If you decline to request a Regulatory Conference or submit a written response, you relinquish your right to appeal the final SDP determination, in that by not doing either, you fail to meet the appeal requirements stated in the Prerequisite and Limitation sections of Attachment 2 of IMC 2519P.

Please contact M. Scott Freeman at (404) 997-4437, and in writing, within 10 days from the issue date of this letter to notify the NRC of your intentions. If we have not heard from you within 10 days, we will continue with our significance determination and enforcement decision.

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The final resolution of this matter will be conveyed in separate correspondence. Because the NRC has not made a final determination in this matter, no Notice of Violation is being issued for this inspection finding at this time. In addition, please be advised that the number and characterization of the AV described in the enclosed inspection report may change as a result of further NRC review.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter and its Enclosure will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>.

Sincerely,

/RA/

Jimi T. Yerokun, Director
Division of Construction Inspection

Docket No: 52-027
License No: NPF-93

Enclosure:
Inspection Report No. 05200027/2013008

cc: (See pages 4 – 6)

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The final resolution of this matter will be conveyed in separate correspondence. Because the NRC has not made a final determination in this matter, no Notice of Violation is being issued for this inspection finding at this time. In addition, please be advised that the number and characterization of the apparent violation described in the enclosed inspection report may change as a result of further NRC review.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter and its Enclosure will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>.

Sincerely,

/RA/

Jimi T. Yerokun, Director
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Docket No: 52-027
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cc: (See pages 4 – 6)

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*See previous concurrence

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ADAMS: Yes ACCESSION NUMBER: ML13085A058 SUNSI REVIEW COMPLETE FORM 665 ATTACHED

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**U.S. NUCLEAR REGULATORY COMMISSION
Region II**

Docket No: 05200027

License No: NPF-93 (Unit 2)

Report No: 05200027/2013-008

Licensee: South Carolina Electric and Gas

Facility: V.C. Summer Nuclear Station Unit 2

Location: Jenkinsville, SC

Inspection Dates: September 10, 2012 – February 12, 2013

Inspectors: Anthony F. Ponko, Construction Inspector, CIB2
Bradley Davis, Senior Construction Inspector, CIB2

Accompanying Personnel: Jimi Yerokun, Director, Division of Construction Inspection
Kathleen O'Donohue, Branch Chief, CIB 2

Approved by: Kathleen F. O'Donohue, Branch Chief
Construction Inspection Branch 2

SUMMARY OF FINDINGS

Inspection Report (IR) 05200027/2013-008; 09/10/2012 through 02/12/2013; V.C. Summer Nuclear Station Unit 2; Unit 2 ITAAC 761 (3.3.00.02a.i.b), Unit 2 ITAAC 762 (3.3.00.02a.i.c), Unit 2 ITAAC 763 (3.3.00.02a.i.d)

This report covers an announced Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) inspection performed by regional based construction inspectors. One ITAAC finding and apparent violation were identified consistent with the NRC Enforcement Policy, Section 2.3 and the temporary enforcement guidance outlined in enforcement guidance memorandum (EGM)-11-006. The significance of most findings is indicated by their color (Green, White, Yellow, Red) using Inspection Manual Chapter (IMC) 2519P, "Construction Significance Determination Process," (SDP). Crosscutting aspects were determined using IMC 0613P, Appendix F, "Construction Crosscutting Components and Aspects." The Nuclear Regulatory Commission's (NRC) program for overseeing the safe construction of commercial nuclear power reactors is described in IMC 2506, "Construction Reactor Oversight Process General Guidance and Basis Document."

A. NRC-Identified and Self Revealed Findings

Cornerstone: Design/Engineering

- TBD: An ITAAC finding and apparent violation (AV) of Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix B, Criterion III, "Design Control," was identified by the inspectors on February 12, 2013, regarding the licensee's failure to assure that applicable regulatory requirements were correctly translated into design specifications, drawings, procedures, and instructions. Specifically, the anchorage and spacing of the headed shear reinforcement in various structural components of the nuclear island (NI), as detailed in the final design documents, did not conform to the provisions of the "Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01)," as required by the Updated Final Safety Analysis Report (UFSAR). The licensee entered this issue into their corrective action program as PIP 0-L-12-0610 to evaluate the deficiency, and to develop and implement any necessary corrective actions.

The inspectors determined the performance deficiency (PD) was more than minor because, if left uncorrected, it represents a condition adverse to quality that renders the quality of a structure, system, or component (SSC), unacceptable or indeterminate. Additionally, the licensee's failure to assure that the requirements of the UFSAR were correctly translated into design specifications, drawings, procedures, and instructions, if left uncorrected, could adversely affect the closure of an ITAAC. The finding was determined to be an ITAAC finding because it is material to the acceptance criteria of Unit 2 ITAAC 761, 762, and 763. The acceptance criteria of these ITAAC require that reconciliation reports concluding the as-built construction conforms to the approved design are completed for the areas associated with each ITAAC.

This finding resulted in deviations from the design that would not have been analyzed by the licensee as required by the ITAAC. The inspectors assessed the finding using the SDP and determined that it is potentially of low to moderate safety significance (White), because reasonable assurance was not provided that a portion of the structure in the high-risk column of the Construction Significance Determination Matrix could meet its intended design function. The affected areas include the critical sections of the NI

basemat and the auxiliary building walls along column lines (CL) 1, 7.3, and L. The final significance of this finding is to be determined. The inspectors screened the finding for a possible construction crosscutting aspect (CCA) and determined that it was not related to any of the CCA discussed in IMC 0613P.

REPORT DETAILS

1. CONSTRUCTION REACTOR SAFETY

Cornerstones: Design/Engineering, Procurement/Fabrication, Construction/Installation, Inspection/Testing

2503 Inspection, Tests, Analysis, and Acceptance Criteria (ITAAC)-Related Work Inspections

.1 ITAAC Numbers 761, 762, and 763 / Family 01F (Unit 2)

a. Inspection Scope

The inspectors reviewed information submitted by the licensee during the inspection period, addressing Unresolved Item (URI) 05200027/2012-004-002, to determine if a violation of regulatory requirements existed. The inspectors compared the information provided with the requirements of the UFSAR to determine if the anchorage and spacing of the headed shear reinforcement conformed to the approved standards. As necessary, the inspectors engaged the Office of New Reactors (NRO) to assist with the evaluation of technical and licensing issues that came up during the inspection.

b. Findings

Failure to assure that applicable regulatory requirements were correctly translated into design specifications, drawings, procedures, and instructions as required by Criterion III of 10 CFR 50, Appendix B.

Introduction:

An ITAAC finding and apparent violation of 10 CFR, Appendix B, Criterion III, "Design Control," were identified by the inspectors on February 12, 2013, regarding the licensee's failure to correctly translate regulatory requirements into design specifications, drawings, procedures, and instructions. Specifically, the anchorage and spacing of the headed shear reinforcement in multiple structural components NI, as detailed in the final design documents, did not conform to the provisions of ACI 349-01, as required by the UFSAR. The significance of this finding is to be determined.

Description:

The nuclear island structures, including the critical sections listed in Table 3.3-7, are identified as Seismic Category I in UFSAR, Tier 1 Section 3.3. Seismic Category I structures are those that must be designed to withstand design basis loads, including the Safe Shutdown Earthquake (SSE), without loss of structural integrity and any safety-related functions. The design and analysis procedures for Seismic Category I structures are described in UFSAR, Tier 2 subsection 3.8.4.4.1, with Tier 2* information designated in accordance with UFSAR Introduction Section 3.5. Subsection 3.8.4.4.1 states in part:

[The design and analysis procedures for the seismic Category I structures ... are in accordance with ACI-349 for concrete structures...]...*

[The criteria of ACI-349, Chapter 12, are applied in development and splicing of the reinforcing steel....]...*

*[Sections 21.2 through 21.5 of Chapter 21 of ACI-349 are applicable to frame members resisting earthquake effects. These requirements are considered in detailing structural elements subjected to significant flexure and out-of-plane shear. These elements include the following examples described in Appendix 3H:]**

- Reinforcement details for the basemat are described in subsection 3.8.5. *[Shear stirrups have T headed anchors at each end.]**
- Reinforcement details for the exterior walls below grade are described in subsection 3.H.5.1.1. *[Shear stirrups have T headed anchors at each end.]**

The 2001 edition of ACI 349 (ACI 349-01) is identified as the applicable code edition and designated as Tier 2* information in UFSAR Tier 2 subsection 3.8.4.2.

Section 11.5.3 of ACI 349-01 requires, in part, that stirrups or other bars used as shear reinforcement be anchored at both ends to develop the design yield strength of the reinforcement.

Section 11.5.4.1 of ACI 349-01 requires, in part, that the spacing of shear reinforcement placed perpendicular to the axis of the member shall not exceed $d/2$ in non-prestressed members. The variable “d” is defined in Section 11.0 of ACI 349-01 as the “distance from extreme compression fiber to centroid of longitudinal reinforcement...”

Section 12.6.2 of ACI 349-01 requires that the mechanical anchorage of reinforcement be designed in accordance with Appendix B, Steel Embedments, of the same standard. Additionally, Section 3.8.5.5 of the UFSAR requires, in part, that the design and construction of anchors conform to the procedures and standards of Appendix B to ACI 349-01.

On October 10, 2012, the licensee provided information to address the URI. In this submittal, the licensee failed to adequately address all the potential failure modes for anchors in tension identified in Appendix B to ACI 349-01, asserting that the concrete breakout limit state was not a credible failure mode for headed shear reinforcement. The inspectors concluded that the design method presented by the licensee to justify the adequacy of the headed shear reinforcement in the 18-inch thick areas of the NI basemat at the elevator and sump pits was incomplete and potentially non-conservative, calling into question the technical justification for the use of headed shear reinforcement in other areas as well. As a result, the inspectors notified the licensee on October 10, 2012, that the issue of concern was a performance deficiency and that the concerns extended to the use of headed shear reinforcement throughout the NI.

On November 12, 2012, the licensee provided additional information to address the URI. In this submittal, the licensee asserted that headed shear reinforcement was approved during the design certification of the AP600 as a “special system of design or construction” in accordance with Section 1.4 of ACI 318/349, and that this approval extended to the use of headed shear reinforcement in the AP1000 design. Furthermore, the licensee maintained that the design of headed shear reinforcement was granted an exemption from the mechanical anchorage provisions of ACI 349 during the design certification of the AP600. To support their position, the licensee pointed to relevant

sections of NUREG 1512, the Final Safety Evaluation Report (FSER) for the AP600, as well as, docketed correspondence between Westinghouse and the NRC concerning issues associated with the design and detailing of the AP600 basemat. The inspectors engaged the Office of New Reactors (NRO) to assist with the review and evaluation of this information. Based on the review of available documentation, staff concluded that headed reinforcement was not approved as a “special system of design or construction” during the AP600 and AP1000 design certifications, and the design and detailing of headed shear reinforcement was required to meet all relevant provisions of ACI 349-01, as a condition of the Combined Licenses (COLs) for Units 2 and 3. This information was communicated to the licensee in a conference call on November 20, 2012.

During the inspection, the inspectors determined that the specified 6-inch spacing of the headed shear reinforcement in the 18-inch thick areas of the NI basemat at the elevator and sump pits, as detailed on construction drawings VS2-1000-CR-002-R1, VS2-1000-CR-003-R1, VS2-1010-CR-011-R3, VS2-1210-CR-903-R3, and VS2-1210-CR-907-R4, exceeded the maximum spacing prescribed in Section 11.5.4.1 of ACI 349-01. The maximum vertical stirrup spacing provisions of ACI 349-01 ensure that a potential crack, assumed to be at a 45 degree angle to the axis of the member, will be intercepted by at least one stirrup in the tension side of the member. Spacing in excess of the code prescribed limit may negate the contribution of the stirrups to the shear resistance of the member, resulting in a capacity less than required by analysis. As a result, the affected structural components may be subject to failure at a demand less than required by the design bases loads. Through an extent of condition review, conducted in response to the URI, the licensee determined that the spacing of the shear reinforcement in some of the walls of the NI exceeded the code prescribed maximum spacing as well. The affected locations include the following areas that fall within walls designated as critical sections in UFSAR Table 3.3-7, “Nuclear Island Critical Structural Sections”:

- auxiliary building wall along CL 7.3 from approximately elevation (EL) 155'-6" to the roof
- auxiliary building wall along CL L from approximately EL 135'-3" to EL 154'-2"
- PCS storage tank walls

The inspectors also determined that the embedment depth of the headed shear reinforcement in 18-inch thick areas of the NI basemat at the elevator and sump pits, as detailed on the construction drawings referenced above, did not meet the requirements of ACI 349-01. Specifically, the embedment depth of the headed shear reinforcement, as measured from an assumed critical section located at half the depth of the member ($d/2$), was insufficient to preclude a non-ductile failure of the anchor at a capacity less than the yield strength of the reinforcement as required by Section 11.5.3 of ACI 349-01, based on the provisions of Section B.5.2 of the same standard. As a result, the structural components that rely upon this system may be subject to brittle failure at a demand less than that required by the design bases loads. Through subsequent inspection activities, the inspectors determined that this performance deficiency extended to the use of headed shear reinforcement in other areas as well. The affected

locations include the following areas that fall within walls designated as critical sections in UFSAR Table 3.3-7, "Nuclear Island Critical Structural Section":

- auxiliary building wall along CL 1 from approximately EL 66'-6" to EL 100'-0"
- auxiliary building wall along CL L from approximately EL 117'-6" to EL 135'-3"

Additionally, the licensee indicated that the 6'-0" thick areas of the basemat, including the two critical sections identified in UFSAR Table 3.3-7 were also affected. A full extent of condition review, however, was not provided to the inspectors.

The inspectors further determined that final design documents for the NI basemat and auxiliary building walls along CLs 1, 7.3, and L had been completed and issued for construction. The inspectors were not able to verify the status of the final design documents for the PCS storage tank walls, or if these walls utilized headed or conventional shear reinforcement. The inspectors also determined that installation of headed shear reinforcement in the NI basemat was in progress. Given the stage of construction, however, installation of headed shear reinforcement in the auxiliary building walls had not yet started.

On December 17, 2012, the licensee provided technical justification for the headed shear reinforcement in the NI basemat. This information consisted of calculations APP-1010-CCC-009-R1, APP-1010-CCC-010-R1, and APP-1010-CCC-011-R0 along with presentation material titled "Response to URI on Shear Ties." In this submittal, the licensee's approach was to demonstrate compliance with Appendix B to ACI 349-01 by showing that the headed shear reinforcement, as detailed in licensee's final design documents, satisfied all credible limit states of anchors in tension. The licensee demonstrated compliance with the limit states of steel strength of anchor in tension, pullout strength of an anchor in tension, and concrete side-face blowout strength of anchor in tension through use of the equations provided in the code. To address the limit strength of concrete breakout of anchor in tension, the licensee used a strut-and-tie model, as codified in Appendix A to ACI 349-06, to support their position that this is not a credible limit state, based on their determination that compression struts forming within the member would preclude this failure mode.

Based on a review of publicly available technical research and engineering papers, the inspectors determined that it is not reasonable to conclude that the embedment depth of an anchor is not relevant to its capacity simply based on equilibrium from a strut-and-tie model developed in accordance with Appendix A to ACI 349-06, and that doing so is also inconsistent with Section A.4.3 of ACI 349-06. The provisions of Appendix A to ACI 349-06 require that tie reinforcement be adequately anchored and specify the location at which the reinforcement needs to be fully developed. The available research data indicates that the anchorage of a headed bar is dependent on the size of the head and the embedment depth, among other factors. In the Concrete Capacity Design (CCD) method for anchorage provided in Appendix B to ACI 349-01, embedment is addressed by the concrete breakout limit state. The inspectors concluded that without a check of this limit state or an alternate limit state accounting for embedment depth, the design method used by the licensee for the anchorage of the headed shear reinforcement is incomplete and may yield non-conservative results. A review of alternate design methods for the anchorage of headed reinforcement that are based on and correlated with testing data supports this conclusion. The inspectors were not able to independently verify the technical adequacy of the headed shear reinforcement

system, as detailed in the licensee's final design documents, nor has the licensee provided adequate technical justification for the anchorage of the system. The inspectors also determined, through independently generated calculations, that the anchorage of the headed shear reinforcement in the 18-inch thick areas of the NI basemat at the elevator and sump pits, as well as, the auxiliary building walls along CL 1 and L, was not in conformance with the code requirements for the mechanical anchorage of reinforcement. These non-conformances did not present an immediate safety concern because the project is still in construction. The licensee indicated that they planned to address the non-conformances in the NI basemat prior to concrete placement through revisions to the physical configuration of the 18-inch thick areas at the elevator and sump pits, along with use of alternate design and acceptance criteria for headed shear reinforcement provided in the "Building Code Requirements for Structural Concrete (ACI 318-11)." These proposed changes to the licensing basis were addressed in License Amendment Request (LAR) 13-02, "Request for License Amendment: Basemat Shear Reinforcement Design Details," dated January 18, 2013. The licensee had not completed evaluating options for addressing the non-conformances in the auxiliary building walls by the end of the inspection.

Analysis:

The licensee's failure to assure that applicable regulatory requirements were correctly translated into design specifications, drawings, procedures, and instructions, as required by Criterion III of 10 CFR Part 50, Appendix B, was identified as a PD. This PD was considered more than minor because, if left uncorrected, it represented a condition adverse to quality that renders the quality of a structure, system, or component (SSC), unacceptable or indeterminate; and the PD is associated with a deficiency in the design and construction of a SSC, which required either a detailed engineering justification, redesign, or rework to establish the adequacy of the SSC to perform its intended safety function. Additionally, this PD was considered more than minor because it adversely affected the objective of the Design/Engineering cornerstone, and, if left uncorrected, could adversely affect the closure of an ITAAC. As a result, this PD is considered a finding.

The finding was determined to be an ITAAC finding because it was material to the acceptance criteria of Unit 2 ITAAC 761, 762, and 763. The acceptance criteria of these ITAAC require that reconciliation reports concluding the "as-built" construction conforms to the approved design are completed for the areas associated with each ITAAC. This finding resulted in deviations from the design that would not have been analyzed by the licensee as required by the ITAAC.

The inspectors assessed the ITAAC finding in accordance with Inspection Manual Chapter (IMC) 2519P, "Construction Significance Determination Process – Pilot." This finding is associated with a failure to appropriately address design requirements - spacing and anchorage - for a headed shear reinforcement system important to the acceptable performance of a number of primary structural components, including some designated as critical sections in USFAR Table 3.3-7. While the spacing and size of the headed shear reinforcement varies within these components, the same system was specified, and the same design requirements for spacing and anchorage apply. At the time of the inspection, the design and detailing of most, if not all, of these components were complete and drawings had been released for construction; installation of headed shear reinforcement in the basemat, including the critical sections, was in process. The

probability of identifying and correcting this deficiency after completing the design and releasing construction drawings was minimal, as there were no planned quality assurance reviews in the licensee's program of a nature that could reasonably have been expected to identify and preclude these deficiencies from being constructed. Given the commonality in the headed shear reinforcement system and associated design requirements, the multiple examples of deficiently designed, and in some cases installed, structural components were considered to be the result of the same PD. These examples include the following:

1. Anchorage and spacing of the headed shear reinforcement in the 18-inch thick areas of the NI basemat at the elevator and sump pits; not in conformance with the requirements of the code. These areas are in the intermediate column of the risk importance table.
2. Anchorage of the headed shear reinforcement in the 6-foot thick areas of the NI basemat, including critical sections identified in UFSAR Table 3.3-7; not in conformance with Appendix B to ACI 349-01 according to the licensee. The basemat, in general, is in the intermediate column of the risk importance table, while the critical sections are in the high-risk column.
3. Anchorage of the headed shear reinforcement in the below grade exterior wall of the auxiliary building along CL 1; not in conformance with the code. This wall is designated as a critical section in UFSAR Table 3.3-7, and, as such, is assigned to the high-risk column of the risk importance table.
4. Anchorage and spacing of the headed shear reinforcement in various interior walls of the auxiliary building, including the critical sections identified in this report; not in conformance with the code. The walls, in general, are in the intermediate column of the risk importance table, while the critical sections are in the high-risk column.

Because technical justification demonstrating the adequacy of the specified headed shear reinforcement system - based on acceptance criteria generally recognized to be reliable for predicting behavior and demonstrating adequacy, such as conformance with a proven comprehensive design model applicable to headed shear reinforcement, or reliance on relevant testing data bounding all configurations - was not provided for review, the inspectors were not able to conclude with reasonable assurance that the structural components that rely upon this system would satisfactorily perform their intended design functions. As a result, the inspectors determined that the finding was potentially associated with Row 2 of the Construction Significance Determination Matrix. Some of the affected areas are listed as critical sections in UFSAR Table 3.3-7, and assigned to the high-risk column of the Construction Significance Determination Matrix. As result, the inspectors concluded that the finding was potentially of low to moderate safety significance (White) because reasonable assurance was not provided that a portion of the structure in the high-risk column of the Construction Significance Determination Matrix could meet its intended design function. The affected areas include the critical sections of the NI basemat and the auxiliary building walls along column lines (CL) 1, 7.3, and L. The final significance of this finding is to be determined.

The inspectors screened the ITAAC finding for a possible construction crosscutting aspect (CCA) in accordance with Appendix F to IMC 0613P, "Power Reactor Construction Inspection Reports – Pilot." The inspectors determined that this finding was not related to any of the construction crosscutting aspects discussed in IMC 0613P.

Enforcement:

Criterion III, "Design Control," of Appendix B, Quality Assurance Program Criteria for Nuclear Power Plants and Fuel Processing Plants, to Title 10 of the Code of Federal Regulations (CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," states, in part, that measures shall be established to assure that applicable regulatory requirements are correctly translated into specifications, drawings, procedures, and instructions.

UFSAR Section 3.8.4.4.1 requires, in part, that the design and analysis procedures for the Seismic Category I structures are in accordance with ACI 349-01 for concrete structures.

Section 11.5.3 of ACI 349-01 requires, in part, that stirrups or other bars used as shear reinforcement be anchored at both ends to develop the design yield strength of the reinforcement.

Section 11.5.4.1 of ACI 349-01 requires, in part, that the spacing of shear reinforcement placed perpendicular to the axis shall not exceed $d/2$ in non-prestressed members. The variable "d" is defined in Section 11.0 of ACI 349-01 as the "distance from extreme compression fiber to centroid of longitudinal tension reinforcement..."

Section 12.6.2 of ACI 349-01 requires that mechanical anchorages be designed in accordance with Appendix B – Steel Embedments. Additionally, Section 3.8.5.5 of the UFSAR states, in part, that the design and construction of anchors conform to the procedures and standards of Appendix B to ACI 349-01.

Contrary to the above, on or before September 10, 2012, the licensee failed to correctly translate regulatory requirements into design specifications, drawings, procedures, and instructions as required by Criterion III, of Appendix B to 10 CFR Part 50. Specifically, the anchorage and spacing of the headed shear reinforcement in multiple structural components of the NI, as detailed in the final design documents, did not comply with the provisions of ACI 349-01, as required by the UFSAR. This finding and AV is evidenced by the following examples:

1. The spacing of the headed shear reinforcement in the NI basemat and walls exceeded the maximum spacing allowed by Section 11.5.4.1 of ACI 349-01 at various locations, including the following:
 - 18-inch thick areas of NI basemat at elevator and sump pits
 - auxiliary building wall along CL 7.3 from approximately elevation (EL) 155'-6" to the roof
 - auxiliary building wall along CL L from approximately EL 135'-3" to EL 154'-2"
2. The embedment depth of the headed shear reinforcement at various locations in the NI basemat and walls was insufficient to preclude a non-ductile failure of the anchor at a capacity less than the yield strength of the reinforcement, as required by Section 11.5.3 of ACI 349-01, based on the provisions of Section B.5.2 of the same standard. As a result, the structural components that rely upon this system may be subject to

brittle failure at a demand less than that required by the design basis loads. These components include the following:

- nuclear island basemat, including critical sections identified in UFSAR Table 3.3-7
- auxiliary building wall along CL 1 from approximately EL 66'-6" to EL 100'-0"
- auxiliary building wall along CL L from approximately EL 117'-6" to EL 135'-3"

This is an ITAAC finding and apparent violation, the final significance of which is to be determined. (AV 05200027/2013-008-01, Anchorage and Spacing of Headed Shear Reinforcement in Structural Components of the NI)

2. OTHER ACTIVITIES

OA3 Follow-up of Licensee Reports, NOVs, and Notices of Enforcement Discretion

.1 Unresolved Item 05200027/2012-004-001 (Closed)

a. Inspection Scope

As described in Section 2503.1 of this report, the inspectors reviewed the information provided by the licensee to address URI 5200027/2012-004-001 to determine if a violation of regulatory requirements existed. The inspectors compared the information provided with the requirements of the UFSAR to determine if the anchorage and spacing of the headed shear reinforcement conformed to the approved standards. As necessary, the inspectors engaged the assistance of the licensing and engineering branches of NRO to evaluate technical and licensing issues that came up during the inspection.

b. Findings

One finding was identified by the inspectors as described in Section 2503.1 of this report. This URI is closed.

OA6 Meetings, Including Exit

On December 21, 2012, the inspectors presented the interim inspection results to Mr. Jeffrey Archie, members of his staff, and representatives of the consortium. On February 12, 2013, the inspectors re-exited with Mr. Archie, members of his staff, and representatives of the consortium. The findings provided during the re-exit were acknowledged by Mr. Archie and other representatives present. The inspectors stated that no proprietary information would be included in the report.

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

05200027/2013-008-01	AV	Anchorage and Spacing of Headed Shear Reinforcement in Structural Components of the NI (Section 1.2503.1)
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Closed

05200027/2012-004-01	URI	Shear Stirrup Anchorage and Spacing in 18-inch Thick Areas of NI Basemat (20A3.1)
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LIST OF DOCUMENTS REVIEWED

ITAAC Numbers 761, 762, and 763:

Calculations:

APP-1010-CCC-009 Revision 1, Detailed Design of T-headed Shear Reinforcement in the Nuclear Island Basemat

APP-1010-CCC-010 Revision 1, Strut-and-Tie Model for T-headed Bars acting as Shear Reinforcement inside the Nuclear Island Basemat below the Elevator Pit

APP-1010-CCC-011 Revision 0, Strut-and-Tie Model (STM) for T-headed Bars acting as Shear Reinforcement inside the Nuclear Island Basemat

Miscellaneous:

V.C. Summer Updated Final Safety Analysis Report (UFSAR)

NUREG-1512, Final Safety Evaluation Report Related to Certification of the AP600 Standard Design

NUREG-1793, Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design, Initial Report and Supplements 1 & 2.

Response to URI on Shear Ties; SCE&G, Santee Cooper, Shaw, Westinghouse Electric Company, December 17, 2012*

URI Response to Design of T-Headed Shear Reinforcement in AP1000 Elevator Pit, Westinghouse Electric Company, November 13, 2012

Headed Shear Reinforcement Discussion, Westinghouse Electric Company, October 10, 2012*

Revised Response to Request for Information (RFI): NI Basemat Reinforcement Details at Sumps and Elevator Pits, Westinghouse Electric Company, October 4, 2012

Response to Request for Information (RFI): NI Basemat Reinforcement Details at Sumps and Elevator Pits, Westinghouse Electric Company, September 24, 2012

LENTON TERMINATOR for Rebar Anchorages, ERICO International Corporation, 2011

LENTON TERMINATOR "D6" Embedment Anchor, ERICO International Corporation, 2009

*Material not dated. Date listed is date provided to the NRC.

Codes and Standards:

ACI-ASCE Committee, "Guide to Shear Reinforcement for Slabs (ACI 421.1R-08)," American Concrete Institute, 2008

International Association of Plumbing and Mechanical Officials (IAPMO), Evaluation Report Number 0188, 2012

- ASTM International, "Standard Specification for Headed Steel Bars for Concrete Reinforcement (ASTM A970/A970M-12)," 2012
- ASTM International, "Standard Specification for Headed Steel Bars for Concrete Reinforcement (ASTM A970/A970M-09)," 2009
- ASTM International, "Standard Specification for Headed Steel Bars for Concrete Reinforcement (ASTM A970/A970M-04a)," 2004
- ASTM International, "Standard Specification for Welded or Forged Headed Bars for Concrete Reinforcement (ASTM A970/A970M-98)," 1998
- ASTM International, "Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete (ASTM A1044/A1044M-05)," 2005

Specifications:

- APP-CR01-Z0-011, Furnishing of Safety Related Reinforcing Steel, Westinghouse Safety Class C "NUCLEAR SAFETY RELATED"
- APP-CC01-Z0-031, Safety Related Placing Concrete and Reinforcing Steel, Westinghouse Seismic Category I Safety Class C "NUCLEAR SAFETY"

Drawings:

- VS2-0000-C9-001-R1, AP1000 Concrete General Notes
- VS2-0000-C9-001-R2, AP1000 Concrete General Notes
- VS2-1000-CR-001-R1, Nuclear Island Basemat Bottom Reinforcement
- VS2-1000-CR-002-R1, Nuclear Island Basemat Top Reinforcement
- VS2-1000-CR-003-R1, Nuclear Island Basemat Shear Reinforcement
- VS2-1000-CR-901-R3, Nuclear Island Basemat Reinforcement Sections
- VS2-1000-CR-904-R3, Nuclear Island Basemat Reinforcement Details
- VS2-1010-CR-005-R1, Nuclear Island Basemat Dowel Plan at El. 66'-6" Aux. Building Area 1
- VS2-1010-CR-006-R1, Nuclear Island Basemat Dowel Plan at El. 66'-6" Aux. Building Area 2
- VS2-1010-CR-007-R1, Nuclear Island Basemat Dowel Plan at El. 66'-6" Aux. Building Area 3
- VS2-1010-CR-008-R1, Nuclear Island Basemat Dowel Plan at El. 66'-6" Aux. Building Area 4
- VS2-1010-CR-009-R1, Nuclear Island Basemat Dowel Plan at El. 66'-6" Aux. Building Area 5
- VS2-1010-CR-010-R1, Nuclear Island Basemat Dowel Plan at El. 66'-6" Aux. Building Area 6
- VS2-1010-CR-011-R3, Nuclear Island Basemat Sections & Details
- VS2-1210-CR-901-R3, Auxiliary Building Basemat Reinforcement Sections NS and Details El. 66'-6"
- VS2-1210-CR-902-R3, Auxiliary Building Basemat Reinforcement Sections EW and Details El. 66'-6"
- VS2-1210-CR-903-R3, Auxiliary Building Reinforcement Details Pit and Sump Area El. 66'-6"
- VS2-1210-CR-907-R4, Auxiliary Building Reinforcement Details Pit and Sump Area El. 66'-6"
- VS2-1000-C8H-800001-R0, Nuclear Island Basemat Bottom Reinforcement – Layer 1
- VS2-1000-C8H-800012-R0, Nuclear Island Basemat Bottom Reinforcement – Layer 1
- VS2-1000-C8H-800013-R0, Nuclear Island Basemat Bottom Reinforcement – Layer 1
- VS2-1000-C8H-800016-R0, Nuclear Island Basemat Bottom Reinforcement – Layer 2
- VS2-1000-C8H-800002-R0, Nuclear Island Basemat Bottom Reinforcement – Layer 2
- VS2-1000-C8H-800003-R0, Nuclear Island Basemat Bottom Reinforcement – Layer 2
- VS2-1000-C8H-800017-R0, Nuclear Island Basemat Top Reinforcement – Layer 4
- VS2-1000-C8H-800020-R0, Nuclear Island Basemat Top Reinforcement – Layer 5
- VS2-1000-C8H-800021-R0, Nuclear Island Basemat Top Reinforcement – Layer 5
- VS2-1000-C8H-800010-R0, Nuclear Island Basemat Shear Reinforcement – Plan
- VS2-1000-C8H-800011-R0, Nuclear Island Basemat Shear, Sump & Pit Reinf. – Sections

Engineering and Design Coordination Reports (E&DCRs):

APP-0000-GEF-007 Rev. 0, Rebar Terminator Head Size Requirements

VSG-CC01-GEF-000028 Rev. 0, Rebar Terminators

Design Change Proposals:

APP-GW-GEE-4022, "Revision to Spacing of Shear Reinforcement under Sump and Elevator
Pits Nuclear Island Basemat"

Corrective Action Documents

CR#554151

IR#12-341-M054

PIP Serial No: 0-L-12-0610