May 17, 2012

MEMORANDUM FOR: Mark E. Tonacci, Chief
Licensing Branch 4 (LB4)
Division of New Reactor Licensing
Office of New Reactors

FROM: Brian Hughes, Senior Project Manager ***/RA/***
Licensing Branch 4 (LB4)
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: U. S. NUCLEAR REGULATORY COMMISSION AUDIT REPORT FOR THE WILLIAM STATES LEE III COMBINED OPERATING LICENSE APPLICATION REVIEW RELATED TO STRUCTURE SEISMIC INTERACTION

On April 9-11, 2012, U.S. Nuclear Regulatory Commission (NRC) staff performed an audit of supporting seismic and structural calculations supporting the design of the William Lee Nuclear Station (WLS). The audit was held at Westinghouse Electric Corporation (WEC) offices in Cranberry Township, Pennsylvania. The summary of the audit discussion and findings is described below.

Background

In December 2007, Duke Energy Carolinas, LLC (the applicant), submitted an application for a combined operating license (COL) for two Westinghouse AP1000 reactors designated as WLS, Units 1 and 2. The WLS site is located near Gaffney, South Carolina. WLS Final Safety Analysis Report (FSAR), Rev 4 Sections 3.7 and 3.8 incorporate by reference AP1000 Design Control Document (DCD) Sections 3.7 and 3.8, and address applicable COL action items.

The staff's review of WLS FSAR Sections 3.7 and 3.8 has identified several issues that have resulted in requests for additional information. The most notable examples include:

(a) Soil uniformity below adjacent structures and the nuclear island (NI).

(b) Potential for amplification of seismic demands on adjacent structures due to granular fill placed over rock.

(c) Potential for amplification of seismic demands due to deep concrete fill placed beneath the NW corner of Unit 1.

(d) Design of concrete fill, particularly below the NW corner of Unit 1.

The purpose of this audit was to verify the adequacy of the technical basis supporting those responses.

Regulatory Audit Bases

WLS FSAR Section 3.7 is being reviewed by the staff in accordance with the relevant requirements of Title 10 of the *Code of Federal Regulations (*10 CFR) Part 50 and Part 100. The regulatory basis of the information incorporated by reference is addressed in the Final Safety Evaluation Report (SRP) Related to Certification of the AP1000 Standard Design, NUREG-1793 and its supplements. In addition, the acceptance criteria associated with the relevant requirements of the Commission regulations (General Design Criteria (GDC) GDC 2 of Appendix A to 10 CFR Part 50; Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants" to 10 CFR Part 50; and 10 CFR 100.23, "Geologic and seismic siting criteria") for the seismic design guidance and parameters are given in Section 3.7.1 of NUREG-0800.

For FSAR Section 3.8.5, the acceptance criteria associated with the relevant requirements of the Commission regulations (GDC 1, GDC 2, GDC 4, and GDC 5, "Sharing of Structures, Systems, and Components" of Appendix A to 10 CFR Part 50; 10 CFR 50.55(a) and Appendix B, to 10 CFR Part 50) for the foundations are given in Section 3.8.5 of NUREG-0800.

Audit Discussion(s)

The applicant presented a summary of the seismic analysis approach and results which included a discussion of assumptions made for site response and soil-structure interaction (SSI) calculations. The applicant also described the approach for performing FIRS calculations including discussion of performing site response calculations for separate fill types characterized by their Unified Soil Classification system as GW, GP and SW. The SSI calculations were performed by WEC for the applicant. The characterization of uncertainty in analysis of granular fill supporting adjacent structures was discussed and WEC presented results of SSI calculation using the best-estimate profile definitions for each of the GW, GP and SW fill characterizations. There was also a discussion of treatment of the uncertainty in the NI SSI calculation.

Analysis of Adjacent Buildings

The applicant reported that the calculations supporting the response to RAI 3.7.1-4 have not yet been completed. However, the applicant described the approach for performing the analysis. The applicant plans to include soil cases to incorporate the uncertainty in shear wave velocity profiles for the granular fill material. The applicant also identified an FSAR 2.5.4 commitment to ensure as-placed fill properties are comparable to those assumed in site-specific analysis. The staff review of the applicant's approach found it to be reasonable and recommended that the applicant consider guidance in Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition NUREG-0800 (SRP) 3.7.2 for addressing uncertainty in SSI analysis. The staff identified an acceptable minimum coefficient of variation (COV) for the fill to be 0.5. The applicant also agreed to consider the use of site-specific

measurements to confirm the appropriate COV at the time of construction. The staff informed the applicant that the acceptability of FSAR commitment could not be assessed until after the results of adjacent structures analyses are reviewed. The applicant projects a late-June completion date.

The staff review of the SSI calculations determined that the applicant's assumptions for backfill degradation models using three potential definitions of GW (well graded gravels), GP (poorly graded gravels) and SW (well graded sands) material gradations appeared to have inconsistent results in that the assumptions for the GP fill led to degradation models equivalent to SW materials. The applicant agreed to address the issue in the final analysis of the adjacent buildings.

MSE Wall

The applicant provided a brief presentation on how they plan to utilize a gabion/MSE wall to support fill adjacent to the NI. The staff noted that the position of the wall is directly below the adjacent structures. During the discussion, the applicant described that the MSE wall not have a substantive impact on the seismic response of the adjacent structures because the wall will be constructed out of the same material as the backfill material (gabion wall). While staff found the response to be reasonable, staff informed the applicant that a formal question request for additional information (RAI) will be issued and that appropriate FSAR revisions should be included in the RAI response. The applicant also discussed construction loads and mentioned that they plan to utilize the same heavy lift derrick configuration that is being used for construction of Vogtle Units 3 and 4. The applicant reported that the heavy-lift derrick foundations will be appreciably far from the NI foundation walls. However, the applicant did not specify the distance of the derrick foundation elements from the NI. Staff informed the applicant that an RAI will be issued so that the impact of construction loads can be reviewed.

Nuclear Island SSI Calculations

NRC staff performed a review of the NI calculation which made use of seismic ground motion incoherency models. Staff specifically performed a review of SSI transfer functions and found that they did not show unstable response and that they reflected the coherence functions referenced in ISG-01. No issues were identified with the incorporation of incoherency in the analysis.

To verify time-history inputs used by the applicant, staff performed a review of Geoscience Calculation, DUK-001-CALC-01, "Development of Artificial Time Histories for Lee Unit 1-Concrete Spectra". The time history seed was defined as the Chi-Chi event 0142 in the NUREG/CT-6728 data base (M>7, D=50-100 km, WUS Rock bin). The smoothing window used in Duke's PSD calculations were stated to be ± 20% as used in Appendix A of SRP Section 3.7.1 (SRP page 3.7.1-22) and is therefore acceptable. No issues were identified, but staff requested electronic files to assist in verifying smoothing functions.

Staff review noted that the Unit 1 NI SSI calculation considered only a best-estimate shear wave velocity profile. SRP Section 3.7.2 requires the use of lower bound, best-estimate, and upper bound shear wave velocity profiles to account for uncertainty in SSI analysis. The applicant responded that the 2D calculation results (shown in response to RAI-3.7.2-1) indicated that the

response of the NI is relatively insensitive to the concrete fill material below the NW corner of the Unit 1NI. The applicant agreed to revise the response to RAI 3.7.2-1 to include justification for using only best-estimate profile in the 3D NI calculation.

In review of the applicant's two-dimensional SSI models, performed to assess the sensitivity of concrete and granular backfill materials, staff noted that the applicant had not described the significance of the discontinuity at the model boundary (e.g., sensitivity of lateral extent). The applicant agreed to assess the significance of the boundary condition and include discussion in the revised response to RAI 3.7.2-1.

Concrete Fill Design

Staff performed a review of the applicant's approach for designing the concrete fill material supporting the NW corner of Unit 1. Staff review of the presentation material noted that additional justification was needed for the maximum coefficient of friction assumed in concrete fill design. The applicant's analysis approach did not consider the effect of water table on the friction coefficient or the absence of steel reinforcement. In addition, the staff noted that the calculation should consider the effect of NI uplift (under SSE loading) and consequent increase in horizontal shear demand. The staff also questioned the applicant's approach of using Boussinesq equations for analyzing the inhomogeneous fill materials below and adjacent to the NI. In response to these issues, the applicant agreed to revise response to RAI 3.8.5-5.

Waterproofing Membrane

The applicant presented the approach for designing the NI waterproofing membrane. The applicant intends to use one of the DCD Section 3.4.1.1.1.1 waterproofing design options and noted its commitment to meet a friction coefficient ITAAC. Staff noted that since the applicant was not committing to a specific design option at the application stage, they would have to inform the staff of the design selection, prior to installation. In response to this issue, the applicant agreed to revise the RAI-3.8.5-06 (waterproofing membrane) response to include within the construction schedule for ITAAC closure and a letter within 60 days of membrane selection.

Conclusion

At the audit exit meeting, NRC staff informed the applicant that the audit was productive and that the support by WEC and contractors led to quick resolution of technical questions. The significant audit action is for the applicant to complete the seismic analysis of buildings adjacent to the NI (planned for late-June, 2012). Staff will audit the supporting calculation(s) once submitted.

Docket Nos.: 52-018 and 52-019

Enclosures:
1. List of Attendees
2. Audit Plan

cc w/encls: See next page

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DATE	05/11/2012	05/17/2012	05/17/2012

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WILLIAM STATES LEE III
AUDIT
APRIL 10, 2012

List of Attendees

Name	Organization
**Mohammed Sku	USNRC
**Bret Tegeler	USNRC
**Jim Thornton	Duke
*Bob Morgan	Duke
*Tom Slavonic	Enercon
*Norman Simms	Duke
*Blaise Genes	GAI Consultants/WEC
*Donald Lindgren	Westinghouse, AP1000 Licensing
*Anthony Sicari	Westinghouse, AP1000 Licensing
*Jill Watson	Westinghouse
*Michael Kavan	Westinghouse
Mark Lloyd	Westinghouse
*Vaughn Thomas	USNRC
*Pravin Patel	USNRC
Tom Houston	Consultant To USUNR
Carl Costaretino	GCA
*Michael Gray	Lettis Consultants, Inc.
*Robert Turner	Fugro Consultants
Lee Tunon-Sanjur	Westinghouse
*John McConaghy	Duke

Name	Organization
*Brian Hughes	NRC
William LaPay	Westinghouse
Jianhua Li	AMEC
*Clay Sams	AMEC

**--Via Phone
*--Attended EXIT Portion of Meeting

Plan for U.S. Nuclear Regulatory Commission Staff Audit
of Duke Energy Carolinas, LLC
Seismic and Structural Calculations Supporting
William Lee Nuclear Station Units 1 and 2

Background

In December 2007, Duke Energy Carolinas, LLC (the applicant), submitted an application for a combined operating license (COL) for two Westinghouse AP1000 reactors designated as William Lee Nuclear Station (WLS), Units 1 and 2. The WLS site is located near Gaffney, South Carolina. WLS Final Safety Analysis Report (FSAR) Sections 3.7 and 3.8 incorporate by reference AP1000 Design Control Document (DCD) DCD Sections 3.7 and 3.8 and address applicable COL action items.

Thus far, the staff's review of WLS FSAR Sections 3.7 and 3.8 has identified several issues that have resulted in requests for additional information. The most notable examples include:

(a) Soil uniformity below adjacent structures and the nuclear island.

(b) Potential for amplification of seismic demands on adjacent structures due to granular fill placed over rock.

(c) Potential for amplification of seismic demands due to deep concrete fill placed beneath the NW corner of Unit 1.

(d) Design of concrete fill, particularly below the NW corner of Unit 1.

The applicant has provided responses to staff questions in the above areas. The purpose of this audit is to verify the adequacy of the technical basis supporting those responses.

Regulatory Audit Bases

WLS FSAR Section 3.7 is being reviewed by the staff in accordance with the relevant requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 and Part 100. The regulatory basis of the information incorporated by reference is addressed in NUREG-1793 and its supplements. In addition, the acceptance criteria associated with the relevant requirements of the U.S. Nuclear Regulatory Commission (Commission) regulations (General Design Criteria (GDC) GDC 2 of Appendix A to 10 CFR Part 50; Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants" to 10 CFR Part 50; and 10 CFR 100.23, "Geologic and seismic siting criteria") for the seismic design parameters are given in Section 3.7.1 of NUREG-0800. For FSAR Section 3.8.5, the acceptance criteria associated with the relevant requirements of the Commission regulations (GDC 1, GDC 2, GDC 4, and GDC 5, "Sharing of Structures, Systems, and Components" of Appendix A to 10 CFR Part 50; 10 CFR 50.55(a) and Appendix B, to 10 CFR Part 50) for the foundations are given in Section 3.8.5 of NUREG-0800.

Regulatory Audit Scope or Methodology

Details regarding the site-specific seismic analysis and the design of foundation fill will be reviewed by staff and used to support the evaluation of Sections 3.7.1, 3.7.2, and 3.8.5. Calculations supporting the applicant's request for additional information (RAI) responses to RAIs **3.7.1-4, 3.7.2-1, and 3.8.5-05** will be reviewed**.** In particular, the staff plans to audit calculations supporting the applicant's approach for:

1. Performing site-specific seismic analysis of the Unit 1 nuclear island (**RAI 3.7.2-1**)

2. Evaluating the effects of the concrete fill material, including the Unit 1, NW corner on seismic response of the AP1000 nuclear island (**RAI.3.7.2-1**).

3. Implementing ground motion incoherency in the seismic analysis (**RAI.3.7.2-1**).

4. Demonstrating that the AP1000 Standard Design envelopes the site-specific seismic evaluation performed for Unit 1 (**RAI 3.7.2-1**).

5. Demonstrating that the selected backfill materials (supporting adjacent structures) are bounded by those considered in the AP1000 DCD (**RAI.3.7.1-4)**

6. Demonstrating adequacy of the design for concrete fill/features supporting the NW corner of Unit 1 (**RAI 3.8.5-5)**

    a. Clarification of referenced American Concrete Institute (ACI) code provisions.
    b. Clarification of design analysis approach and assumptions
    c. Clarification of margin to code allowable(s) for fill concrete material and coefficient of friction.

7. Consideration of loads encountered during construction (**SRP Section 3.8.4)**

Audit Task 1 (Day 1)

Applicant to provide overall summary of seismic analysis approach and identify DCD departures.

Audit Task 2 (Days 1, 2)

Review the assumed soil-structure interaction (SSI) input parameters (e.g., input control motion, shear wave velocity profiles, etc.) and approach for which seismic ground motion incoherency was accounted for in SASSI analysis.

Audit Task 3 (Days 1, 2, 3)

Review ISRS comparisons to AP1000 DCD and key locations (include vertical comparisons).

Audit Task 4 (Days 2, 3)

Review basis for concrete fill design (NW corner)

Information and Other Material Necessary for the Regulatory Audit

1. Applicant letter responses to the below mentioned open NRC staff RAIs.
2. Access to SASSI input decks relating to applicant's site-specific analysis

Team Assignments

Brian Hughes, NRC, Project Manager
Bret Tegeler, NRC, Seismic Analysis
Pravin Patel, NRC, Structural Design
Vaughn Thomas, NRC, Structural Design
Carl Costantino, NRC Consultant, Seismic Analysis
Thomas Houston, NRC Consultant, Structural Design

Logistics

The audit will be conducted at the Westinghouse offices in Cranberry, Pennsylvania, and will begin on April 9, 2012. An escort is requested to meet the audit team in the lobby of the building at 12:45 pm on the first day. The entrance briefing is scheduled for 1:00 p.m. An exit briefing will be tentatively scheduled for Thursday morning (note that this may change according to the requirements of the audit and the availability of principals).

All material subject to the site visit (hard copy or electronic) will be left at the site. If any documentation is required to support the staff's regulatory findings, the staff will identify it in a RAI.

Special Requests

Please make a space available for the team members to meet privately and discuss the progress of the audit. Audit team members will bring computers for note taking and preparation of a report on the audit. Access to relevant calculation reports and supporting documents (e.g., AP1000 DCD) would make the audit more effective and efficient. In addition to workspace with power for the team's computers, please provide access to a local or network printer and an Ethernet connection to the Internet by which the team can remotely access computer resources at the NRC. (Additional computer monitors would also be helpful.) Finally, please arrange a teleconference line to permit the project manager, SEB1 branch chief, and others at NRC headquarters to participate as needed.

Deliverables

A summary report of the audit will be prepared and issued in accordance with NRO-REG-108.

References

1. NRO-REG-108, “Regulatory Audits,” April 2, 2009

2. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants.”

3. AP1000 DCD, Revision 19

4. “AP1000 Standard Combined License Technical Report Effect of High Frequency Seismic Content on SSCs” (TR-115), Revision 3, June 2010.

5. WLS FSAR, Revision 4, Sections 2.5.4, 3.7 and 3.8

COL - Duke Energy - Lee Mailing List (Revised 03/15/2012)

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Public Citizens Critical Mass Energy
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ORIGINATOR: **B. Hughes**

SUBJECT: **NRC AUDIT REPORT FOR THE WILLIAM STATES LEE III COL APPLICATION REVIEW RELATED TO STRUCTURE SEISMIC INTERACTION (SSI)**

SECRETARY: **C. Nagel**

DATE: **May 17, 2012**

●●● ROUTING LIST ●●●

	NAME	DATE
1.	R. Butler (ARedden for)	05/11/12
2.	B. Hughes	/ /12
3.	B. Tegeler	/ /12
4.	Secretary	/ /12

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