June 23, 2010

Ms. Dee M. Xenakis, Manager
Global Quality Programs
Westinghouse Electric Company
1000 Westinghouse Drive, Suite 131
Cranberry Township, PA 16066

SUBJECT: NRC INSPECTION REPORT NO. 05200006/2010-201

Dear Ms. Xenakis:

On May 11 - 13, 2010, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an inspection at the Westinghouse Electric Company (hereafter referred to as WEC) facility in Cranberry Township, PA. The purpose of the inspection was to perform a limited scope inspection to assess the quality activities implemented to control the use of a macro code used in the design of nuclear island structures of the AP1000 design. The NRC staff reviewed policies and procedures associated with the use of computer programs in safety-related analyses, including verification, validation, and changes to computer programs. The NRC staff also reviewed the independent reviews performed by Westinghouse on the nuclear island concrete reinforcement design provided by its subcontractors. The results of the inspection determined that the Westinghouse QA program is being effectively implemented for the scope of the areas reviewed. No findings have been identified as a result of this inspection. The enclosed report presents the results of this inspection. This NRC inspection report does not constitute NRC endorsement of your overall quality assurance (QA) or 10 CFR Part 21 programs.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosures, and your response will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's document system (ADAMS), accessible at http://www.nrc.gov/reading-rm/adams.html.

Sincerely,

***/RA/***

Juan Peralta, Chief
Quality and Vendor Branch 1
Division of Construction Inspection
& Operational Programs
Office of New Reactors

Docket No. 05200006

Enclosures:
1. Inspection Report No. 05200006/2010-201 and Attachment

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Global Quality Programs
Westinghouse Electric Company
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Quality and Vendor Branch 1
Division of Construction Inspection
& Operational Programs
Office of New Reactors

Docket No. 05200006
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1. Inspection Report No. 05200006/2010-201 and Attachment

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ADAMS Package Accession No.: ML101550162 *concurred via email

| OFFICE | NRO/DE/SEB1 | NRO/DCIP (contractor) | RES/DE/DICB | NRO/DCIP/CQVA | NRO/DCIP/CQVA:BC |
|---|---|---|---|---|---|
| NAME | JMa * | IAlsamsam * | MConcepcion * | KKavanagh | JPeralta |
| DATE | 6/4/2010 | 6/7 /2010 | 6/7 /2010 | 6/11 /2010 | 6/23/2010 |

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**U.S. NUCLEAR REGULATORY COMMISSION**
**OFFICE OF NEW REACTORS**
**DIVISION OF CONSTRUCTION INSPECTION AND OPERATIONAL PROGRAMS**

| | |
|---|---|
| Docket No.: | 05200006 |
| Report No.: | 05200006/2010-201 |
| Vendor: | Westinghouse Electric Company<br>1000 Westinghouse Drive<br>Cranberry Township, PA 16066 |
| Vendor Contact: | Ms. Dee Xenakis, Manager<br>Global Quality Programs<br>(412) 374-6593<br>E-mail: xenakidm@westinghouse.com |
| Nuclear Industry Activities: | Westinghouse Electric Company provides fuel, services, technology, plant design, and equipment to utility and industrial customers in the worldwide commercial nuclear electric power industry. |
| Inspection Dates: | May 11 - 13, 2010 |
| Inspectors: | Kerri Kavanagh — NRO/DCIP/CQVA, Team Leader<br>Milton Concepcion — RES/DE/DICB<br>John Ma — NRO/DE/SEB1<br>Iyad (Ed) Alsamsam — NRO/DCIP contractor |
| Approved by: | Juan Peralta, Chief<br>Quality and Vendor Branch A<br>Division of Construction Inspection<br>& Operational Programs<br>Office of New Reactors |

ENCLOSURE

## EXECUTIVE SUMMARY

Westinghouse Electric Company
05200006/2010-201

The purpose of this limited scope inspection was to verify that Westinghouse Electric Company (WEC) implemented adequate quality assurance (QA) policies and procedures to control the use of the WEC ANSYS macro code used to design nuclear island structures of the AP1000 design. The WEC ANSYS macro code has also been used to design reinforced concrete and concrete filled steel plates. This limited scope inspection also verified that the QA policies and procedures related to the use of the WEC ANSYS macro code complied with the applicable requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10 of the *Code of Federal Regulations (10 CFR)* Part 50, "Domestic Licensing of Production and Utilization Facilities." The inspection was conducted at the WEC facility in Cranberry Township, PA, during the period May 11 - 13, 2010.

The following regulations served as the bases for the NRC inspection:

- Appendix B to 10 CFR Part 50
- 10 CFR Part 21

The NRC inspection team implemented Inspection Procedure (IP) 35017, "Quality Assurance Implementation Inspection," during the conduct of this inspection.

The NRC had previously performed an inspection at the WEC facility in Monroeville, PA. in October 2008 and the results of that inspection are documented in Inspection Report (IR) Number 05200006/2008-201. The nonconformances identified in IR 05200006/2008-201 were not reviewed as part of this limited scope inspection.

The NRC inspection team concluded that the WEC QA policies and procedures comply with the applicable requirements of Appendix B to 10 CFR Part 50. The NRC inspection team further concluded that WEC personnel were implementing these policies and procedures effectively.

Design Control

The NRC inspection team concluded that WEC design control process conforms to regulatory requirements and has been implemented in accordance with applicable WEC policies and procedures. The NRC inspection team concluded that WEC confirmed, through validation tests, that both ANSYS macro and Excel spreadsheet may be used to calculate reinforcement, but the NRC inspection team determined that one is not capable of verifying the adequacy of the other since both implement the same methodology adopted by WEC to calculate reinforcement. Additionally, the NRC inspection team verified that the Excel spreadsheet output, which indicated Vc was negative, was not a technical error.

Control of Purchased Material, Equipment, and Services

The NRC inspection team concluded that WEC controls of purchased materials, equipment, and services are consistent with the regulatory requirements of Criterion VII of Appendix B to 10 CFR Part 50. Based on the documents reviewed, the NRC inspection team also determined that related policies and procedures were being effectively implemented. No issues of significance were identified.

## REPORT DETAILS

1. Design Control

   a. Inspection Scope

   The NRC inspection team reviewed WEC policies and implementing procedures that govern the design control activities to verify compliance with the requirements of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50. Specifically, the NRC inspection team reviewed the following:

   - APP-GW-S1-008, Revision 1, "Design Guide for Reinforcement in Walls and Floor Slabs," dated July 22, 2003
   - APP-1000-CCC-001, Revision 4, "Verification of Design Macro for Reinforced Concrete Walls and Floors," dated September 25, 2009
   - APP-1000-CCC-002, Revision 0, "Guidance on Checking Results of Design Macro Calculation," dated October 2, 2003
   - Westinghouse Procedure NSNP 3.6.1, Revision 2, "Computer Software Development Process," dated February 18, 2010
   - Westinghouse Procedure NSNP 3.6.2, Revision 2, "Validation of Computer Software," dated February 8, 2010
   - Westinghouse Procedure NSNP 3.6.6, Revision 0, "Single Application Computer Programs," dated November 3, 2008

   b. Observations and Findings

   b.1 Structural Design Analysis of AP1000 Nuclear Island in ANSYS

   The NRC inspection team reviewed the WEC design guidelines and selected a sample of calculation packages to verify adequate implementation of the design process used for the calculation of the required reinforcement in walls and floor slabs of the AP1000 nuclear island. The NRC inspection team also held several meetings with WEC structural design team representatives to review the structural engineering software tools and technology employed in the structural design of the AP1000 nuclear power plant.

   The NRC inspection team noted that WEC developed a three dimensional (3D) analytical computer model using a finite element modeling (FEM) proprietary software called ANSYS. The ANSYS model developed by WEC included the containment structure, containment internal structures, shield building, auxiliary building, basemat and supporting soil layers of the AP1000 nuclear power plant. This model has all of the basic design loads applied to corresponding structural elements as well as consideration for seismic input in various forms to simulate the effect of considered earthquakes.

The NRC inspection team reviewed APP-GW-S1-008, which provides guidance on the design of reinforcement in walls and floor slabs of the nuclear island where member forces have been calculated in an ANSYS finite element analysis. This design guide contains the formulas to be used for the calculation of required reinforcement as required in the WEC design criteria for civil and structural design. As stated in the guide, the design of the reinforcement is performed in accordance with the American Concrete Institute (ACI) 349, "Code Requirements for Nuclear Safety-Related Concrete Structures." The NRC inspection team noted that WEC developed computer codes that were written in ANSYS language (called ANSYS macros). The NRC inspection team also noted that WEC developed an Excel spreadsheet to verify the output calculations produced by the ANSYS macro routine.

To perform a wall or slab design, a WEC design engineer invokes a series of ANSYS macros that set up design parameters such as the number of load cases, top and bottom reinforcing bar concrete cover, steel and concrete material strength, and design requirements related to the ACI 349 code. The invoked ANSYS macros return a tabulated summary of forces used for each element and the corresponding calculated reinforcing steel area required, taking into account several design conditions and load combinations. At the user's request, stress contours and other visual aids are generated from the ANSYS model. Reinforcing calculations take into account the axial forces and moments, in-plane shear forces, out-of-plane shear one-way and two-way forces as well as minimum reinforcement limits and alternative design accounting for combination of in-plane shear and torsion. The required calculated reinforcement is further evaluated by the WEC engineer to determine the amount provided in each zone of wall or slab and is ultimately used to finalize the design values presented on the construction drawings.

WEC applied the ANSYS macros for the calculation of design of reinforced concrete walls and floor slabs that can be modeled as a beam action or 2-way action where the design section is assumed to be a plane. As stated in APP-1000-CCC-002, the ANSYS macros are applicable for design of floors and walls that can behave predominantly as a one way (beam member) or two way action (plate member). The applicability of the ANSYS macros to walls or slabs is evaluated in advance by the WEC design engineer using specific guidance provided in APP-1000-CCC-002. The guidance also precludes the use of the ANSYS macro for elements behaving predominantly as axially loaded members (column members). This is further evaluated by the WEC design engineer using stress contours of the structural element or member under consideration. The ANSYS macros communicate with the ANSYS results database for the calculation of required reinforcement in walls and floor slabs of the nuclear island. The NRC inspection team verified that the ANSYS macros and the Excel spreadsheet were developed in accordance with the technical requirements specified in APP-GW-S1-008.

b.2 Verification and Validation (V&V) of ANSYS Macros used in Structural Analyses

The NRC inspection team reviewed the WEC policies and procedures for the planning, development, and retirement of computer software, including single application computer programs, associated with engineering products and services. The NRC inspection team also reviewed a selected sample of calculation packages to verify V&V activities performed by WEC.

The NRC inspection team reviewed WEC procedures NSNP 3.6.2 and NSNP 3.6.6, which define the responsibilities and requirements for the development and design adequacy of single application computer programs. The procedures provide guidance for the validation,

verification, configuration control of computer programs, and generation and maintenance of documentation to ensure that WEC-developed codes satisfy all identified requirements and produce correct results.

The NRC inspection team reviewed WEC calculation package APP-1000-CCC-001, developed to document the validation of the ANSYS macros and an Excel spreadsheet, used in the calculation of reinforced concrete walls and floor slabs in the AP1000 nuclear island. The NRC inspection team noted that the calculation package provided a comprehensive explanation of the ANSYS macros developed by WEC, guidance on the use of inputs, assessment of the calculation results, comparisons to ACI examples, a description of the verification models, and a comparison of the Excel & ANSYS macro results. It also includes a calculation verification checklist to be used by the verifier.

The NRC inspection team reviewed WEC calculation package APP-1000-CCC-002, which is a design procedure for checking the adequacy of design reinforcement where required reinforcement has been calculated using the ANSYS macros described in APP-1000-CCC-001. The NRC inspection team noted that the procedure provides guidance to examine the adequacy of reinforcement, applicability of design reinforcement for members with load cases where both surfaces are in compression, and limits for reinforcement of compression members.

The NRC inspection team noted that validation of the ANSYS macros and the Excel spreadsheet was accomplished by selecting sample problems with known solutions given in the ACI Design Handbook*, "Beams, One-Way Slabs, Brackets, Footings and Pile Caps*," ACI 340.1R-91. These design examples focused on beam action with axial forces and were considered relevant in the calculation of reinforcement. For simple problems, WEC verified the results produced by the ANSYS macros and the Excel spreadsheet results against hand calculations. Additionally, the NRC inspection team noted that WEC compared the ANSYS macros and the Excel spreadsheet calculation results against each other to verify the accuracy of the results obtained.

The NRC inspection team reviewed the verification and validation activities performed by WEC related to the ANSYS macros and an Excel spreadsheet, and confirmed that WEC adequately controlled the ANSYS macros and Excel spreadsheet used in the calculation of reinforced concrete walls and floor slabs in the AP1000 nuclear island, consistent with the WEC QA program and relevant procedures. However, the NRC inspection team determined that the use of the Excel spreadsheet as an independent method to verify the adequacy of the ANSYS macros does not provide independent verification of the results provided by the ANSYS macros. WEC confirmed, through validation tests, that both software tools may be used to calculate reinforcement, but the NRC inspection team determined that one is not capable of verifying the adequacy of the other since both implement the same methodology adopted by WEC to calculate reinforcement. The NRC staff will establish the adequacy of the ANSYS macros for its application to reinforcement steel design through its review and approval of the AP1000 design certification application.

b.3 Resolution of the Negative Concrete Shear Strength Output from the ANSYS Macro Code

The output of a negative concrete shear strength value, Vc, from the Excel spreadsheet developed by WEC, which was displayed on page 421 of the Westinghouse submittal entitled "Design for the AP1000 Enhanced Shield Building," dated August, 2009, prompted the need for an evaluation of the adequacy of the Excel spreadsheet because concrete

shear strength should never be negative. According to WEC, the Excel spreadsheet has been used for verifying the results of ANSYS macros developed by WEC for designing (proportioning) sectional strength of reinforced concrete superstructures and concrete filled steel superstructures and the basemat of the AP1000 nuclear island structure.

The NRC inspection team reviewed the portion of the Excel spreadsheet related to the negative concrete shear strength value, Vc, and found that the value of Vc is actually set to zero in the calculation for the area of shear reinforcing steel when Vc values become negative. Therefore, the Excel spreadsheet output, which indicated Vc was negative, was not a technical error because it did not affect the calculation of the area of shear reinforcing steel. The source of the error was that the code writer forgot to set the Vc value to "zero" in the equation that calculates Vc when the structural member is subjected to a significant tensile force. Therefore, the Excel spreadsheet printed out a negative Vc value when the tensile force was significant.

c. Conclusions

The NRC inspection team concluded that WEC design control process conforms to regulatory requirements and has been implemented in accordance with applicable WEC policies and procedures. The NRC inspection team concluded that WEC confirmed, through validation tests that both ANSYS macro and Excel spreadsheet may be used to calculate reinforcement. However, the NRC inspection team determined that one is not capable of verifying the adequacy of the other since both implement the same methodology adopted by WEC to calculate reinforcement. Finally, the NRC inspection team verified that the Excel spreadsheet output, which indicated Vc was negative, was not a technical error.

2. Control of Purchased Material, Equipment, and Services

a. Inspection Scope

The NRC inspection team reviewed WEC policies and procedures that govern the control of purchased material, equipment, and services to verify compliance with the requirements of Criterion VII, "Control of Purchased Material, Equipment, and Services," of Appendix B to 10 CFR Part 50. The NRC inspection team reviewed the purchase orders (POs), change notices, and associated WEC external audit reports of Obayashi Corporation and Ansaldo Nucleare to evaluate compliance with program requirements and adequate implementation of those requirements. In addition, the NRC inspection team reviewed corrective actions that address deficiencies identified by audit findings for adequacy and timeliness.

Documents reviewed for this area of inspection include the following:

- WEC "Quality Management System" (QMS), Section 4.3, "Procurement," Revision 5, dated October 1, 2002

- PO 4500296198 dated March 9, 2009 and associated change notices 1 through 3 with Obayashi Corporation

- PO 4500299762 dated April 6, 2009 associated change notices 1 through 12 with Ansaldo Nucleare

- APP-GW-GEP-002, “Hardware and Software Requirements for AP1000 Design Partners,” Revision 1, May 6, 2004

- APP-GW-GEP-001, “Technical and Administrative Requirements for Engineering Services for the AP1000 Nuclear Power Plant,” Revision 6, July 1, 2009

- Audit Package for Obayashi Corporation, WES-2010-039, Supplier Quality Program Audit Report, Revision 0, dated April 9, 2010

- WES-2010-039, Supplier Quality Program Audit Report, Revision 1, dated May 11, 2010

- Supplier Corrective Action Request (SCAR) 10-131-M009

- SCAR 10-131-M010

- Audit Package for Ansaldo Nucleare S.p.A, WES-2009-178, Supplier Quality Program Audit Report, dated July 26, 2009

- SCAR 09-198-M002

- SCAR 09-198-M003

- SCAR 09-198-M004

- SCAR 09-198-M006

- SCAR 09-198-M007

b. Observations and Findings

The NRC inspection team reviewed QMS, Section 4.3. Section 4.3 establishes the controls to ensure that purchased material, equipment, and services conform to procurement documents. These controls include supplier evaluations and selections through quality evaluation and rating, periodic source assessments and inspections, audits, and receipt inspections, as applicable.

The NRC inspection team reviewed APP-GW-GEP-001 which establishes the requirements for Engineer (Design Agent) services throughout the design and construction phases, including the necessary scheduling, engineering, documentation and design services for the structures, systems and components. In addition, Section 1.1.13 of APP-GW-GEP-001 states that in cases where the Engineer employs computer codes to perform analysis, specific items shall be provided to WEC as a deliverable associated with the calculation. These items include the data input sheet, description of the code, assumptions made in the code, and output result sheets.

b.1 Obayashi Corporation

The NRC inspection team reviewed the external audit performed by WEC associated with PO No. 4500296198, which includes work associated with basic structural design, settlement analyses, structural steel framing, air inlet concrete behavior study, air inlet modular behavior study, construction studies, and aircraft crash analysis. Structural design includes the auxiliary building and nuclear island. During March 15-16, 2010, WEC performed an audit of Obayashi which indicated that Obayashi was effectively implementing its nuclear QA program specific to procurement activities. The audit identified two audit observations that required evaluation and response by Obayashi and offered two recommendations. The NRC inspection team reviewed the audit, as well as the audit observations and recommendations, and concluded that WEC performed a limited scope audit which effectively verified that Obayashi performed procurement activities consistent with quality requirements that met the applicable requirements of Appendix B. No issues were identified.

b.2 Ansaldo Nucleare

The NRC inspection team reviewed the external audit performed by WEC associated with PO No. 4500299762, which includes work associated with the general design development of the AP1000 containment vessel, containment building, middle and upper containment annulus, a portion of the shield building, including the roof structure, and the main steam isolation valve compartment areas of the auxiliary building. During June 22-26, 2009, WES performed an audit of Ansaldo which indicated that Ansaldo was effectively implementing its nuclear QA program specific to procurement activities. The audit identified five audit observations that required evaluation and response by Ansaldo. The NRC inspection team reviewed the audit, as well as the audit observations, and concluded that WEC performed a limited scope audit which effectively verified that Ansaldo performed procurement activities consistent with quality requirements that met the applicable requirements of Appendix B. No issues were identified.

c. Conclusions

The NRC inspection team concluded that WEC controls of purchased materials, equipment, and services are consistent with the regulatory requirements of Criterion VII of Appendix B to 10 CFR Part 50. Based on the documents reviewed, the NRC inspection team also determined that related policies and procedures were being effectively implemented. No issues of significance were identified.

3. Entrance and Exit Meetings

On May 11, 2010, the NRC inspection team discussed the scope of the inspection with Mr. Gary Brassart, Vice-President of Operational Excellence and Chief Quality Officer, Mr. Sandy Rupprecht, Vice-President of Nuclear Power Plant Licensing, WEC, and with the WEC management, engineering, and administrative staff. On May 13, 2010, the NRC inspection team presented the inspection results and observations during an exit meeting with Mr. Gary Brassart and other Shaw management and engineering staff. The attachment to this report lists the entrance and exit meeting attendees, as well as those interviewed by the NRC inspection team.

## ATTACHMENT

1. ENTRANCE/EXIT MEETING ATTENDEES

| Name | Title | Affiliation | Entrance | Exit | Interviewed |
|---|---|---|---|---|---|
| Nick Scutella | Quality Engineer | WEC | X | X | |
| Kevin Accornero | NPE Special Projects | WEC | X | X | |
| Takashi Otomo | WEC contractor | Obayashi Corporation | X | X | X |
| David Harris | Quality Programs & Supplier Quality | WEC | X | X | |
| Rob Sisk | Mgr AP1000 Licensing | WEC | X | | |
| Karen McCabe | Supply Chain | WEC | X | | |
| Scott Altmayer | Licensing Integration Engineer | WEC | X | | |
| Ed Schmiech | New Plant Engineering | WEC | X | | |
| Dana Woodbury | New Plant Engineering | WEC | X | | X |
| Jerry Roell | Supply Chain Management | WEC | X | | X |
| Mike Melten | Regulatory Affairs | WEC | X | | |
| Dee Xenakis | Mgr Global Quality Programs | WEC | X | X | |
| Michelle C. Merwin | Supplier Quality Assessment | WEC | X | X | |
| Carolyn Monaco | NPP Operational Excellence & Quality | WEC | X | X | |
| John Deblasio | Licensing | WEC | X | X | X |
| Narrender Prasad | NPP Engineering | WEC | X | X | X |
| Sandy Rupprecht | VP NPP Licensing | WEC | X | | |
| Gary Brassart | VP Operational Excellence and Chief Quality Officer | WEC | X | X | |
| Lee Tunon-Sanjur | NPP Engineering | WEC | X | X | X |
| Brandon Schoonmaker | NPP Engineering | WEC | | | X |
| Bruce Bevilacqua | NPP Engineering | WEC | | X | |

2. INSPECTION PROCEDURES USED

IP 35017, “Quality Assurance Implementation Inspection”

3. LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

No items of significance were identified as a result of this inspection.