

October 3, 2011

Mr. Thomas Ray, Manager
COL Licensing Support
Westinghouse Electric Company
1000 Westinghouse Drive, Suite 115
Cranberry Township, PA1606

SUBJECT: AP1000 PRESSURIZED WATER REACTOR DESIGN FOLLOWUP INSPECTION
OF THE AIRCRAFT IMPACT ASSESSMENT, NRC INSPECTION REPORT
NO. 05200006/2011-202 AND NOTICE OF VIOLATION

Dear Mr. Ray:

On May 23, 2011, through August 12, 2011, the U.S. Nuclear Regulatory Commission (NRC) staff conducted a series of site visits and document reviews to perform a followup inspection of the Westinghouse Electric Company (WEC) aircraft impact assessment (AIA) and the WEC Corrective Action Program. The NRC inspection team conducted site visits at the WEC facility located in Cranberry Township, PA, during the weeks of May 23, 2011, and June 20, 2011. In addition, the NRC inspection team requested additional shield building analyses and calculations and reviewed the final results during the week of August 1, 2011. The NRC inspection team also performed a general evaluation of the shield building structural design and reviewed WEC's corrective actions for the violations identified during the initial AIA inspection performed in September 2010. The NRC performed these inspection activities in response to additional questions raised during the NRC's final review of the AP1000 shield building. The enclosed report presents the results from these inspection activities for the portions of the AP1000 AIA included within the scope of this inspection. This inspection report does not constitute NRC's endorsement of the overall AP1000 AIA.

Based on the results of this inspection, the NRC determined that a violation of NRC requirements occurred. The violation is cited in the enclosed Notice of Violation (Notice), and the circumstances surrounding it is described in detail in the subject inspection report. The violation cited that WEC failed to effectively implement corrective actions to verify convergence of the LS-DYNA computer model and to correlate the results to the calculation of record consistent with the requirements of Criterion XVI, "Corrective Actions," to Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," of Title 10 to the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." With the exception of the violation identified in the Notice, the NRC inspection team concluded that the portions of the WEC AP1000 AIA reviewed comply with the applicable requirements of 10 CFR 50.150, "Aircraft impact assessment," and Appendix B to 10 CFR Part 50.

You are required to respond to this letter and should follow the instructions specified in the enclosed Notice when preparing your response. If you have additional information that you believe the NRC should consider, you may provide it in your response to the Notice. The NRC review of your response to the Notice will also determine whether further enforcement action is necessary to ensure compliance with regulatory requirements.

In accordance with 10 CFR 2.390 of the NRC's "Public Inspections, Exemptions, Requests for Withholding," 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 Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. To the extent possible, your response, if applicable, should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request that such material is withheld from public disclosure, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements."

Sincerely,

/RA/

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

Docket No.: 05200006

Enclosures:

1. Notice of Violation
2. Inspection Report No. 05200006/2011-202 and Attachments

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(Revised 06/29/2010)

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NOTICE OF VIOLATION

Westinghouse Electric Company
Cranberry Township, PA 16066

Docket Nos.: 05200006
Inspection Report No.: 05200006/2011-202

During a U.S. Nuclear Regulatory Commission (NRC) followup inspection of the Westinghouse Electric Company (WEC) AP1000 pressurized-water reactor design aircraft impact assessment (AIA), conducted at the WEC facility in Cranberry Township, PA, at separate intervals performed from May 23 through August 12, 2011, a violation of NRC requirements was identified. In accordance with the NRC Enforcement Policy, the violation is listed below:

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.150, "Aircraft impact assessment," Paragraph (a)(1) states, in part, that each applicant listed in 10 CFR 50.150(a)(3) shall perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft. Using realistic analyses, the applicant shall identify and incorporate into the design those design features and functional capabilities to show that, with reduced use of operator actions:

- (i) the reactor core remains cooled, or the containment remains intact; and
- (ii) spent fuel cooling or spent fuel pool integrity is maintained.

Criterion XVI, "Corrective Action," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," states, in part, that "[m]easures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected."

Section 5.5, "Corrective and Preventative Action," within subsection 5.5.1, "General," of the WEC Quality Assurance Manual, requires, in part, that "Conditions adverse to quality or items and services are identified, documented, analyzed, and corrected in accordance with established procedures."

Contrary to the above, as of May 26, 2011, WEC failed to effectively implement corrective actions to assure that a realistic analysis was used to identify and incorporate into the AP1000 design the applicable design features and functional capabilities. Specifically, WEC failed to assure that the LS-DYNA code modeling techniques used in the aircraft impact assessment (AIA) including the mesh densities and the calculated solution time steps were appropriate and sufficient to achieve solution convergence. WEC report APP-S2C-171, "LS-DYNA Time Step Sensitivity Study," showed that certain analysis conditions (i.e., use of a coarse mesh, and a time-step much smaller than the LS-DYNA default value) could lead to a divergent (or unstable) solution causing erroneous results. The inspection team determined that the analysis performed by WEC was insufficient (i.e., comparatively small range of time steps assessed) to address the full range of sensitivities relating to model mesh density and solution time-step, and could not be directly correlated to the calculations of record to demonstrate that the shield building will withstand an aircraft impact.

This issue has been identified as Violation 05200006/2011-202-01.

This is a Severity Level IV Violation (Section 6.5).

Pursuant to the provisions of 10 CFR 2.201, "Notice of Violation," WEC is hereby required to submit a written statement or explanation to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, with a copy to the Chief, Quality and Vendor Branch 1, Division of Construction Inspection and Operational Programs, Office of New Reactors, within 30 days of the date of the letter transmitting this Notice of Violation. This reply should be clearly marked as a "Reply to a Notice of Violation" and should include for each violation (1) the reason for the violation, or, if contested, the basis for disputing the violation or severity level, (2) the corrective steps that have been taken and the results achieved, (3) the corrective steps that will be taken to avoid further violations, and (4) the date when full compliance will be achieved. Your response may reference or include previous docketed correspondence, if the correspondence adequately addresses the required response. Where good cause is shown, the NRC will consider extending the response time.

If you contest this enforcement action, you should also provide a copy of your response, with the basis for your denial, to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001

Because your response 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, accessible at <http://www.nrc.gov/reading-rm/adams.html>, to the extent possible, it should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements."

Dated this the XXth day of September, 2011

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

Docket No.: 05200010

Report No.: 05200010/2011-202

Vendor: Westinghouse Electric Company
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Vendor Contact: Mr. Thomas Ray, Manager
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Nuclear Industry Activities: Westinghouse Electric Company (WEC) has requested to amend the AP1000 pressurized-water reactor (AP1000) design certification to comply with the U.S. Nuclear Regulatory Commission (NRC) requirements in Title 10 of the *Code of Federal Regulation* (10 CFR), Section 50.150, "Aircraft impact assessment."

Inspection Dates: May 23, 2011 - August 12, 2011

Inspectors: Robert Prato, Team Leader NRO/DCIP/CQVA
Bret Tegeler NRO/DE/SEB1
Thomas Kendzia NRO/DCIP/CQVA

Approved by: Juan D. Peralta, Chief
Quality and Vendor Branch 1
Division of Construction Inspection
& Operational Programs
Office of New Reactors

EXECUTIVE SUMMARY

Westinghouse Electric Company
Cranberry Township, PA 16066

Docket No.: 05200006
Inspection Report No.: 05200006/2011-202

The purpose of this U.S. Nuclear Regulatory Commission (NRC) inspection was to verify that Westinghouse Electric Company (WEC) had implemented the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.150, "Aircraft impact assessment," and performed a design-specific assessment¹ of the effects on the facility from the impact of a large, commercial aircraft. The NRC initiated this inspection to perform a final review of the shield building design relative to aircraft impact and to review the corrective actions for the violation identified during the September 27 – October 1, 2010, AP1000 aircraft impact inspection. The current inspection included an indepth review of the engineering details associated with the shield building design conducted over an extended period at the WEC facility in Cranberry Township, PA and at the WEC facility in Rockville, MD during the period May 23 through August 12, 2011.

The following served as the bases for the NRC inspection:

- 10 CFR 50.150
- Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"
- Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50

The NRC inspection team performed a general review of shield building calculations relating to aircraft impact. As part of this review, the inspection team identified an open item in a calculation relating to the aircraft impact structural analyses that raised questions relative to the application of the LS-DYNA computer code (the computer code used to model the applicable structures and the effects of an aircraft impact on those structures). As a result, the NRC inspection team focused part of this inspection on the computer modeling activities performed in support of the aircraft impact assessment (AIA). In addition, the NRC inspection team reviewed the quality assurance corrective action process and activities for the violation cited in the AP1000 AIA inspection report dated October 28, 2010.

The results of this inspection are summarized below.

Review of Shield Building Structural Design Calculations

The NRC inspection team performed a general review of the AP1000 shield building structural design calculations relating to portions of the AIA and verified the accuracy and completeness of the calculations reviewed, as well as compliance with applicable codes and the requirements of 10 CFR 50.150.

¹ By a "design-specific" assessment, the NRC means that the impact assessment must address the specific design of the facility which is either the subject of a construction permit, operating license, standard design certification, standard design approval, combined license, or manufacturing license application (see 74 FR 28129; June 12, 2009).

LS-DYNA Code

The NRC inspection team concluded that the WEC LS-DYNA computer code modeling analysis associated with the shield building AIA initially failed to implement corrective actions to assure that the shield building model used in the AIA was appropriate and sufficient. Specifically, WEC report APP-S2C-171, "LS-DYNA Time Step Sensitivity Study," showed that certain analysis conditions (i.e., use of a coarse mesh, and a time-step much smaller than the LS-DYNA default value) could lead to a divergent (or unstable) solution causing erroneous results. Based on review of this report, the NRC inspection team determined that the analysis performed by WEC was insufficient (i.e., a comparatively small range of time steps were assessed) to address the full range of sensitivities with respect to mesh density and solution time step, and could not be correlated to the "calculations of record." Therefore, the WEC analysis failed to effectively demonstrate the ability of the shield building to withstand an aircraft impact. This issue is identified as Violation 05200006/2011-202-01 in the Corrective Actions section of this report.

Corrective Actions

The NRC inspection team identified Violation 05200006/2011-202-01 associated with WEC's failure to implement the requirements of Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50. Specifically, WEC failed to implement corrective actions to assure that the LS-DYNA code modeling activities were appropriate and sufficient. The mesh densities and the range of time steps initially calculated by the LS-DYNA code and accepted by WEC were significantly narrower than that identified in a WEC peer review problem statement. In addition, WEC performed analyses using simplified calculations but failed to effectively correlate the simplified calculations to the "calculations of record" to demonstrate that the shield building will withstand an aircraft impact.

REPORT DETAILS

1. Shield Building Calculations

a. Inspection Scope

The U.S. Nuclear Regulatory Commission (NRC) inspection team performed a general review of the Westinghouse Electric Company (WEC) AP1000 shield building structural design calculations relating to portions of the AIA to verify the accuracy and completeness of shield building calculations and compliance with applicable codes and the requirements of 10 CFR 50.150.

Specifically, the NRC inspection team reviewed the following shield building structural calculations associated with the design of the shield building cylindrical wall; the design of the conical roof region including steel roof beams; steel concrete (SC) composite to reinforced concrete (RC) mechanical connections; and the connection of the auxiliary building roof with the shield building SC wall for this inspection area:

- APP-1208-CCC-003, "Design of Enhanced Shield Building Mechanical Connections at 100', 149'-6", and Along Column Lines N & Q," Revision 0, issued March, 2011.
- APP-1200-CCC-119, "Shield Building Cylindrical Wall Reinforcement Design," Revision 9, dated June 6, 2011.
- APP-1278-CCC-001, "Enhanced Shield Building Roof Design-Conical Roof-Equivalent Static Analysis," Revision 5, dated June 20, 2011.
- APP-1260-CCC-002, "Auxiliary Building Concrete Slab Design" Elevation 160'-6", Areas 3 & 4," Revision 1, issued August 2010.

b. Observations and Findings

b.1 Shield Building Cylindrical Wall Reinforcement Design

The NRC inspection team reviewed WEC calculation APP-1200-CCC-119 and identified several localized areas where calculated demands appeared to exceed the code- values required by American Concrete Institute (ACI)-349. The inspection team discussed these exceedances with WEC design engineers. WEC noted that the exceedances were in localized areas (e.g., near door openings and penetrations) and that additional reinforcement would be utilized in accordance with ACI-349. The NRC inspection team concluded that WEC's justification for the exceedances to be reasonable, but determined that the justification needed to be effectively documented in the calculation report. In response, WEC issued Corrective Action Report (CAR) 11-174-M027 to revise APP-1200-CCC-119 to ensure that the justification for the exceedances is more clearly documented and to document the methods used in the reinforcement analyses in more detail.

b.2 Enhanced Shield Building Roof Design-Conical Roof-Equivalent Static Analysis

The NRC inspection team reviewed WEC calculation APP-1278-CCC-001 and the design specifics for the reinforced concrete conical roof region. The inspection

team determined that the calculated demand-to-capacity ratios for the conical region were less than 0.8 (the load requirements is less than 80 percent of the design capacity). In addition, the inspection team noted that the supporting steel beams had demand-to-capacity ratios of less than 0.7 with an assumed steel material yield stress of 36 kilopounds per square inch (ksi). The NRC inspection team verified that calculation APP-1278-CCC-001 was performed in accordance with WEC procedures and acceptable engineering practices, and the results were consistent with ACI-349 code requirements.

b.3 Design of Enhanced Shield Building Mechanical Connections at 100', 149'-6", and Along Column Lines N & Q

The NRC inspection team reviewed calculation APP-1208-CCC-003. The inspection team determined that the calculated results indicated adequate margin consistent with code allowable limits however, the design basis for the applicable connections did not consider the combined effects of thermal and seismic loads on the shield building connections. In response, WEC stated that APP-1208-CCC-003 was being revised in response to Issue Report (IR) 11-138-M013, "Shield Building Seismic and Thermal Issue Raised by NRC," dated May 18, 2011, which states, in part, that all seismic Category I structures will be assessed for the thermal and seismic load combination. Upon effective consideration of thermal and seismic loads, the NRC inspection team verified that calculation APP-1208-CCC-003 was performed in accordance with WEC procedures and acceptable engineering practices, and the results were consistent with the requirements in ACI-349 and American Institute of Steel Construction N690, "Specification for Safety-Related Steel Structures for Nuclear Facilities."

b.4 Auxiliary Building Concrete Slab Design" Elevation 160'-6", Areas 3 & 4

The NRC inspection team reviewed calculation APP-1260-CCC-002. The inspection team noted that while the design of this particular roof slab does not involve a critical (safety related) connection, as described in Appendix 3H, to the AP1000 design control document (DCD), the design of this slab is representative of other seismic Category I roof slab areas. The NRC inspection team determined that the calculated results indicated adequate margin consistent with code-allowable limits, however, the design basis for the applicable connections did not consider the combined effects of thermal and seismic loads on the shield building connections. In response, WEC stated that APP-1260-CCC-002 was being revised in response to Issue Report 11-138-M013, which states, in part, that all seismic Category I structures will be assessed for the thermal and seismic load combination. Upon effective consideration of thermal and seismic loads, the NRC inspection team verified that calculation APP-1260-CCC-002 was performed in accordance with WEC procedures and acceptable engineering practices, and the results were consistent with ACI-349 code requirements.

c. Conclusions

The NRC inspection team concluded that WEC's AP1000 shield building structural calculations were performed in accordance with WEC procedures and acceptable engineering practices, and were in compliance with applicable codes and the requirements of 10 CFR 50.150. No significant findings were identified.

2. LS-DYNA Code

a. Inspection Scope

The NRC inspection team reviewed the LS-DYNA modeling activities related to the AP1000 aircraft impact assessment (AIA) structural analysis to verify compliance with the requirements of 10 CFR 50.150, "Aircraft Impact Assessment." This review included an evaluation of the corrective actions implemented by WEC in response to Issue Report (IR) 10-307-M008, "Severity Level IV Notice of Violation Issued to Westinghouse on October 28th," dated November 3, 2010. IR10-307-M008 was written in response to a WEC peer review to ensure that the LS-DYNA code modeling activities were effectively implemented and reflected a realistic analysis in determining whether the shield building as a design feature is functionally capable of withstanding an aircraft impact. As part of this inspection activity, the NRC inspection team evaluated simplified calculations used by WEC in its LS-DYNA code modeling activities to verify that the calculations used accurately reflected the "calculations of record" and the reported results of the AP1000 AIA.

Specifically, the NRC inspection team reviewed the following AP1000 documents related to the AIA and shield building design:

- APP-1000-GEC-001, "Aircraft Impact Analysis for AP1000 Nuclear Island," Revision 1, dated September 26, 2010.
- APP-1000-GEC-001, "Aircraft Impact Analysis for AP1000 Nuclear Island," Revision 2, dated October 1, 2010.
- WEC peer review presentation material, "AP1000 LS-DYNA AIA Open Item Peer Review," dated September 27, 2010
- Meeting Minutes for "AP1000 LS-DYNA AIA Open Item Peer Review," dated September 27, 2010
- APP-1000-S2C-171, "LS-DYNA Time Step Sensitivity Study," Revision 1, issued May 2011
- APP-1000-S2C-041, "LS-DYNA Benchmarking for Out-of-Plane Shear Test for SC Beam with $a/d=3.5$," Revision 0, dated September 27, 2010.
- IR 10-307-M008, "Severity Level IV Notice of Violation Issued to WEC on October 28th," dated November 3, 2010
- IR 10-267-M026, "Corrective Actions to Address the AIA Mesh and Time-Step Convergence Study Using the Calculation of Record," dated September 24, 2010
- Procedure QP 03-04, "Engineering Peer Review," Revision 7, dated May 1, 2010
- Meeting Minutes DCP 001703, "AP1000 LS-DYNA AIA Open Item Peer Review – Meeting Minutes," dated September 27, 2010

b. Observations and Findings

b.1 Peer Review of the Shield Building LS-DYNA Code Model:

In an Issue Report, IR 10-307-M008, WEC acknowledged a potential technical issue associated with the time step and mesh density sensitivity applicable to the LS-DYNA shield building modeling activities performed as part of the AIA.

IR 10-307-M008 states that “[a] concern has been identified regarding the potential non conservative results presented in the report. Further investigations are required for the corresponding time-history analyses performed, based on sensitivity studies of associated mesh and time step selections to confirm the adequacy of the true structural response presented for the aircraft and missile impact scenarios.”

WEC closed the open item on the bases of recommendations from an independent peer review panel and sensitivity studies described in APP-1000-S2C-171, “LS-DYNA Time Step Sensitivity Study.” The report focused on model benchmarking as well as the effects of time step control and mesh density in conjunction with the use of the Winfrith concrete model. The report concluded that the modeling techniques used, the mesh density used and the use of the time step automatically calculated by the LS-DYNA code are appropriate and sufficient for the AIA.

The NRC inspection team reviewed the corrective actions performed in response to IR 10-307-M008 and determined that the WEC performed the time step sensitivity study was performed on a representative model of the shield building. The sensitivity analysis used a segment of a full size cylindrical wall with steel plate reinforcement and a relatively coarse mesh and subsequent more refined meshes of the same wall. The sensitivity study results indicated that certain analysis conditions (i.e., use of a coarse mesh, and a time-step much smaller than the LS-DYNA default value) could lead to a divergent (or unstable) solution causing erroneous results.

Based on a review of the sensitivity study and supporting information, the NRC inspection team found that the analysis performed by WEC was insufficient (i.e., a comparatively small range of time steps assessed) to address the full range of mesh densities and solution time steps to effectively confirm the adequacy of the true structural response of the shield building credited in the AIA. On this basis, the inspection team found that the implemented corrective actions did not adequately address the issue defined in IR 10-307-M008 or the open items from the AIA inspection. In addition, the inspection team determined that the results of the sensitivity study performed using simplified calculations could not be directly extended to the calculation of record. To address this issue, WEC initiated IR 10-267-M026 to perform a mesh and time-step convergence study using the calculation of record.

b2. Mesh and Time-Step Convergence Study

To verify the structural response of the shield building as credited in the AIA, WEC performed additional AIA sensitivity studies using the commercial LS-DYNA computer code. The purpose of these studies was to confirm the stability and convergence of the AIA analysis results. WEC developed detailed shield building model and a simplified half-cylinder model for the purpose of performing a wide range of analysis cases. These models were used to evaluate increasing levels of mesh refinement and corresponding, decreasing solution time-steps. Analysis results indicated that the shield building model converged over the revised range of mesh densities and solution time steps applied in the expanded sensitivity

study and that an aircraft impact from a large commercial aircraft would not perforate the shield building.

The NRC inspection team reviewed the revised AIA report and verified that the applicant had included the results of the revised sensitivity study as well as the updated results of the shield building analysis. The inspection team reviewed the revised AIA results and found that WEC had analyzed an effective range of mesh densities and solution time-steps to adequately demonstrate solution convergence. Although, the predicted deformations of the AP1000 shield building wall had increased, the detailed analysis results indicated that maximum strains remained below the failure limits referenced in the Nuclear Energy Institute guidance document, NEI-07-13. Therefore, the original conclusion that the shield building can withstand the effects of an aircraft impact consistent with the requirements of 10 CFR 50.150 was confirmed. Based on the broad range of sensitivity analyses and the revised shield building analysis performed consistent with the "calculation of record," the NRC inspection team concluded that the original WEC AIA conclusions, described in Appendix 19F of Chapter 19 to AP1000 DCD remain valid.

c. Conclusions

The NRC inspection team concluded that the shield building can withstand the effects of an aircraft impact consistent with the requirements of 10 CFR 50.150. Based on its review, the NRC inspection team determined that the original WEC AIA conclusions, described in Appendix 19F of Chapter 19 to AP1000 DCD remain valid.

3. Corrective Action Program

a. Inspection Scope

The NRC inspectors reviewed WEC's policies and procedures that govern the corrective action process to ensure that they adequately describe the process and implement the requirements of Criterion XVI, "Corrective Actions," of Appendix B to 10 CFR Part 50. The NRC inspection team reviewed WEC's corrective action program and activities, including documentation and records, and discussed the corrective action process with responsible WEC management and staff.

Specifically, the NRC inspectors reviewed the following documents:

- "Quality Management System," Revision 6, dated April 8, 2011
- WEC 1.1, "Management Review," Revision 10, dated January 31, 2011
- WEC 3.3.1, "Design Reviews," Revision 2, dated November 1, 2010
- WEC 16.2, "Westinghouse Corrective Actions Process," Revision 2, dated February 8, 2010
- WEC 16.3, "Corrective Action Review Board," Revision 1, dated August 3, 2009
- WEC 16.4, "Root Cause Analysis," Revision 1, dated August 3, 2009
- WEC 16.5, "Apparent Cause Analysis," Revision 0, dated November 3, 2008
- WEC 16.9, "Trending Process," Revision 0, dated February 8, 2010
- WEC 21.0, "Identification and Reporting of Conditions Adverse to Safety," Revision 6, dated August 3, 2009

- ES 21.1, "WEC 21.0 Level 3 Implementation Procedure," Revision 1, dated December 6, 2010
- Corrective Action Program (CAPs) Overview Training, revised October 2008
- Corrective Action Program (CAPs) Issue Owner Training, revised February 2011
- Corrective Action Program (CAPs) Issue Owner Role in Causal Analysis, Revision 3
- Apparent Cause Analysis (ACA) Training, Revision 13
- Root Cause Analysis (RCA) Training 2011, Revision 0
- Correct Action Review Board (CARB) Training, Revision 3
- APP-GW-GAP-408, "Control and Application of the Revised AP1000 DCD," Revision 0, dated November 11, 2009
- Westinghouse AP1000 Design Control Document, Revision 18, Section 9.5.1.2.1.1, "Plant Fire Prevention and Control Features"
- APP-GW-GEP-010, "Process & Procedure for AP1000 Internal Open Items," Revision 4, dated July 13, 2010
- APP-GW-GEE-2450, "Relocation of AIA Blast Doors and of Shielding Doors to Annulus Personal Access Portals," Revision 0, dated February 28, 2011
- APP-GW-GEE-1078, "Resizing Ancillary Diesel Generator for Starting Motor Current," Revision 0, dated April 5, 2010
- APP-GW-GEE-1059, "PCS Design Changes," Revision 0, dated October 1, 2009
- PI-11-01, "Scaling Calculation Incorrect for Determining Time to Achieve Steady State Water Coverage for the AP1000," dated January 11, 2011
- LTR-SRC-11-11, "Closing Request for PI-11-11, Scaling Calculation Incorrect for Determining Time to Achieve Steady State Water Coverage for the AP1000," dated February 16, 2011
- IRM Agenda: 5-26-11 – MP-11-21
- WCAP-15846, "WGOthic Application for AP600 and AP1000," Revision 1
- Internal Audit Report WEC-10-42, "AP1000 Projects – International and NPP Engineering Contracts"
- PowerPoint presentation titled, "FY09 Management Review, Westinghouse QMS, NPP," dated June 11, 2010
- Calculation Note No. CN-CRA-01-62, "Development of the WGOthic AP1000 Containment Evaluation Model Input Deck," Revision 0, dated October 15, 2001
- APP-GW-GLR-096, "Evaluation of the Effect of the AP1000 Enhanced Shield Building Design on the Containment Response and Scale Analyses," Revision 2, dated May 8, 2011
- APP-SSAR-GSC-193, "Scaling Calculation for Time to Steady State PCS Film Coverage for the AP1000 Containment Pressure and Temperature Response Analysis," Revision 0, dated February 9, 2011
- NPP-ENG-5248, "Document Management CAPs Error Reduction and Process Improvement," dated September 8, 2009
- Issue Report (IR) 09-037-M008, "Calculation of AP1000 Rx Coolant Loop Pressure Drop," dated February 6, 2009
- IR 09-190-M005, "PCS Water Storage Tank Screens Omitted from AP1000 Safety-Related Equipment Source Document List," dated July 9, 2009
- IR 09-210-M003, "PCS Recirculation Pump Motor Size," dated July 29, 2009
- IR 09-287-M014, "Discrepancy in PCS Documentation for the PCCAWST In-tank Heater Electric Load," dated October 14, 2009

- IR 10-102-M029, "Incorrect Operating Conditions for APP-PV32-Z0D-122," dated April 12, 2010
- IR 10-162-M018, "NPP FY09 MAR Action #8 – Document Inaccuracies," dated June 11, 2011
- IR 10-133-M011, "PXS / RCS Operating Conditions Not Properly Defined," dated May 13, 2010
- IR 10-167-M041, "PCS Recirculation Pump Motor Size," dated June 16, 2010
- IR 10-161-M028, "Open Items Procedures Not Followed in System Specification Documents," dated June 10, 2010
- IR 10-183-M031, "Open Items Not Identified on Concrete Drawings," dated July 2, 2010
- IR 10-217-M009, "DCP 1078 Technical Errors Identified by the NRC," dated August 5, 2010
- IR 10-218-M023, "Steam Generator Secondary Pressure in the PCWG Data Sheets," dated August 6, 2010
- IR 10-246-M011, "Squib Valve Termination Unit Discharge Resistor Design Modification," dated September 3, 2010
- IR 10-307-M008, "Severity Level IV Notice of Violation Issued to Westinghouse on October 28th," dated November 3, 2010
- IR 10-321-M022, "Design Adequacy of AP1000 Squib Valve Control Termination Unit," dated November 17, 2010
- IR 10-327-M033, "Fire Barrier – Aircraft Impact Analysis Barrier Issues," dated November 23, 2010
- IR 10-340-M025, "Scaling Calculation Incorrect for Determining Time to Achieve Steady State Water Coverage for the AP1000," dated December 6, 2010
- IR 11-005-M029, "PCS Valve Room Freeze Mitigation Following a Loss of AC Power," dated January 5, 2011
- IR 11-018-M017, "RAI on AP600 Design – PCS Steady State Water Film Coverage of the Containment Vessel," dated January 18, 2011
- IR 11-021-M011, "Qualification of PPG Coatings for Use on the Containment Vessel," dated January 21, 2011
- IR 11-025-M001, "MAER Input: Error in Title of TWICE Safety System Software Release Record," dated January 25, 2011
- IR 11-025-M003, "Multiple Errors Identified for the AP1000 containment Peak Pressure Calculations," dated January 25, 2011
- IR 11-052-W003, "CAPs Commitments Closed Based on Future Actions," dated February 21, 2011
- IR 11-076-M006, "CAPs Commitments Closed Based on Future Actions," dated March 17, 2011
- IR 11-087-C012, "Issues with the Performance of ACAs across WEC," dated March 28, 2011
- IR 11-096-M004, "Incorrect Fluid Temperature Range Specified for PCS Pumps (MP2P) in functional requirements (APP-PCS-M3C-176 Rev. 1)," dated April 6, 2011
- IR 11-104-M008, "Issue with AP1000 Document APP-PV70-V0-001 Rev 3," dated April 14, 2011
- IR 11-125-M025, "Configuration Control Process Not Followed," dated May 5, 2011

- IR 11-131-M030, “AP1000: ADS Stage 4 Isolation Valve Design Conditions,” dated May 11, 2011
- IR 11-132-M033, “Inconsistent Documentation about PCS Valve Room Heaters,” dated May 12, 2011
- IR 11-136-M044, “Confirm CV Expansion during BDBA to Ensure CV Free Expansion,” dated May 16, 2011
- IR 11-138-M012, “Discrepancy between Shield Building Action Item 21 and DCD Commitment,” dated May 18, 2011
- IR 11-138-M013, “Shield Building Seismic and Thermal Issue Raised by NRC,” dated May 18, 2011
- IR 11-142-M005, “CAPS Commitment Closed on Promise of Future Action,” dated May 22, 2011
- IR 11-143-M055, “Action Required by ACA Not Complete,” dated May 23, 2011
- IR 11-147-M056, “Multiply Errors Identified for the AP1000 Containment Peak Pressure Calculations,” dated May 27, 2011
- IR 11-152-M044, “Improperly Closed CAPS Issues/Commitments from Internal Audits,” dated June 1, 2011
- IR 11-174-M014, “Improper Evaluation of IR 10-183-M031,” dated June 23, 2011

b. Observations and Findings

b.1 Corrective Action Process

The NRC inspection team reviewed the WEC Quality Management System (QMS) and implementing procedure WEP 16.2, which describes the general requirements for implementing the corrective action program, including identification, documentation, tracking, evaluation, causal analysis, and closeout of conditions adverse to quality. The NRC inspection team noted that procedure WEC 16.2 defines a repeat event as a medium/high significance issue attributed to ineffective resolution of a previous high significance issue. The team observes that while the procedure meets the requirements of the QMS and Criterion XVI of Appendix B to 10 CFR Part 50, the very restrictive definition limits the opportunity to identify similar repeat occurrences that could indicate procedure, process, or performance issues before the quarterly and annual trending efforts takes place.

The NRC inspection team reviewed WEP 16.4 and 16.5 which describe the WEC root cause analysis (RCA) and apparent cause analysis (ACA) processes, respectively. The NRC inspection team reviewed the training for root cause and apparent cause evaluators and determined that the training provides adequate guidance for implementing the procedures. The NRC inspection team noted that WEC has the “issue owner” set the scope and perform the review and approval of the apparent cause analysis, however, the “issue owner” is not required to be trained as apparent cause analysis evaluator. (Note: individuals who perform the apparent cause analyses are required to be qualified.) The NRC inspection team observes that while the procedures meet the requirements of the QMS and Criterion XVI of Appendix B to 10 CFR Part 50, having the scope, and the review and approval of apparent cause analysis by an “issue owner” who is not properly trained in apparent cause analysis may not be capable of effectively determining scope or performing an effective review of the apparent cause analyses assigned to that individual.

The NRC inspection team observed a WEC Issue Review Committee (IRC) meeting to assess the IRC process and activities for consistency with WEC 16.2 and WEC 16.3. The IRC encouraged open discussion, assigned appropriate significance to the issues reviewed at the meeting, applied sound judgment in assigning responsibility for individual issues, and performed effective evaluations under 10 CFR Part 21, "Reporting of Defects and Noncompliance." The NRC inspection team noted that the IRC performed cognitive trending of repeat issues and documented the repeated issues in new IRs. The IRC did not direction to the assigned group in terms of what was expected to be addressed in the response. In accordance with WEC 16.3, the determination of what needs to be done to address an issue was left to the expertise of the "issue owner."

The NRC inspection team reviewed one internal audit to determine whether the identified issues were appropriately entered into the corrective action program. The NRC inspection team verified that the issues identified during the internal audit reviewed were entered into the corrective action program.

The NRC inspection team reviewed the corrective action trending procedure and activities to evaluate the WEC trending program for consistency with the QMS. The inspection team reviewed WEC 16.9, "Trending Process." WEC 16.9, Revision 0, was issued February 8, 2010, and had not been implemented long enough to collect meaningful data, however the NRC inspection team did note that trending activities were being performed in preparation for developing the first corrective action trend report. The NRC inspection team observed that quarterly trends were being performed by process codes and not by deficiency or causal codes. Deficiency or causal trends were only performed as part of WEC's annual trending activities. The failure to perform deficiency and causal trending on a quarterly basis could delay the identification of an adverse trend in causal areas such as procedural, programmatic, or human performance.

b.2 Corrective Actions Program Activities

The NRC inspection team reviewed Issue Reports (IRs) associated with the shield building, containment, and passive containment cooling system. The inspection team reviewed 38 of the IRs and associated corrective action packages (CAPs) (approximately 10 percent) to evaluate documentation activities, significance level determination, identification of conditions adverse to quality, documentation of apparent cause (if required), identification of corrective actions to be taken, effective implementation of corrective actions, and evaluation of Part 21 reportability. The sample of IR and CAPs reviewed included varying significance levels as determined by the WEC (Suggestion for Improvement (SFI), Watch/Trend, Medium, and High Significance Issues), as well as other IRs that the NRC inspection team identified as potentially being significant issues. For the IRs reviewed, the NRC inspection team verified that WEC identified and corrected the technical issues associated with the conditions adverse to quality.

The NRC inspection team determined that IR 11-021-M011 was the only report in the sample IRs reviewed that was classified as an issue of high significance requiring a RCA. The applicable RCA was not completed during the inspection period however the NRC inspection team reviewed the ongoing RCA activities. The inspection team determined that the RCA was being performed in

accordance with WEC procedures and that an appropriate level of feedback from the analysis was being provided in accordance with the RCA process.

The NRC inspection team observed that IRs 09-210-M003, 10-218-M023, and 11-021-M011 contained issues requiring corrective actions but the IRs lacked documentation describing the actions that needed to be implemented. However, the NRC inspection team, however, determined that, in all three cases, the required action was in progress or taken in response to another IR or other controlled documentation.

The NRC inspection team identified that IRs 09-190-M005, 09-210-M003, 10-307-M008, and 10-321-M022 that did not address programmatic or human performance deficiencies that were apparent causes of or contributed to the conditions adverse to quality as identified in the applicable IR. IR 11-087-C012 (IR resolution in progress) self identifies that some WEC ACA have not met the procedural requirements, and this specifically included corrective actions not addressing the apparent cause. IR 11-087-C012 was upgraded from a watch trend to a high level significance during the NRC inspection, and will have a RCA performed.

The NRC inspection team reviewed IR 10-183-M031 that was used to document WEC's engineer and management decision to meet schedule, by not following procedure. The IR corrective action did not address the engineer and management decision process. Interviews with the issue owner and ACA performer identified that WEC knew that the IR basis was incorrect and, therefore, no deficiency that required corrective action existed, although that was not documented in the ACA. The NRC inspection team confirmed that the IR basis was incorrect and no condition adverse to quality existed. IR 11-174-M014 was submitted by WEC to reassess IR 10-183-M031 and revise the ACA appropriately. IR 11-174-M014 also suggested additional training for WEC staff.

b.3 Aircraft Impact Assessment Corrective Actions

The NRC inspection team reviewed Title 10, of the *Code of Federal Regulations* (CFR), Section 50.150, "Aircraft impact assessment," Criterion XVI, "Corrective Actions," of Appendix B to 10 CFR Part 50, and the WEC QMS. 10CFR 50.150, Paragraph (a)(1) states, in part, that subject applicants shall perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft. Using realistic analyses, the applicant shall identify and incorporate into the design those design features and functional capabilities to show that, with reduced use of operator actions:

- (i) the reactor core remains cooled, or the containment remains intact; and
- (ii) spent fuel cooling or spent fuel pool integrity is maintained.

Criterion XVI, Appendix B to 10 CFR Part 50 states, in part, that "[m]easures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected." The QMS, Section 5.5.1, requires, in part, that "[c]onditions adverse to quality or items and

services are identified, documented, analyzed, and corrected in accordance with established procedures.”

The NRC inspection team reviewed IR 10-307-M008 associated with the Notice of Violation from the WEC AIA inspection performed by the NRC in October 2010. In IR 10-307-M008, WEC acknowledged a potential issue associated with the sensitivity analysis as part of the shield building modeling activities for the AIA. IR 10-307-M008 states that “[a] concern has been identified regarding the potential non conservative results presented in the report. Further investigations are required for the corresponding time-history analyses performed, based on sensitivity studies of associated mesh and time step selections to confirm the adequacy of the true structural response presented for the aircraft and missile impact scenarios.”

WEC closed the open item on the bases of recommendations from an independent peer review panel and sensitivity studies described in APP-1000-S2C-171, “LS-DYNA Time Step Sensitivity Study.” The report concluded that the modeling techniques used were appropriate and sufficient for the AIA. The NRC inspection team reviewed the corrective actions performed in response to IR 10-307-M008 and determined that the sensitivity study results indicated that certain analysis conditions (i.e., use of a coarse mesh, and a time-step much smaller than the LS-DYNA default value) could lead to a divergent (or unstable) solution causing erroneous results.

Based on a review of the sensitivity study and supporting information, the NRC inspection team found that WEC failed to implement effective corrective actions in response to IR 10-307-M008. Specifically, WEC failed to assess the full range of mesh densities and solution time steps to effectively confirm the shield building structural response and its ability to withstand an aircraft impact as was credited in the WEC AIA. In addition, the inspection team determined that the results of the sensitivity study performed using simplified calculations could not be directly extended to the calculation of record. The NRC inspection team identified this issue as Violation 05200006/2011-202-01.

d. Conclusions

The NRC inspection team identified Violation 05200006/2011-202-01 associated with WEC’s failure to implement the requirements of Criterion XVI of Appendix B to 10 CFR Part 50. Specifically, WEC failed to effectively demonstrate that the model used in the AIA was sufficiently stable over the range of mesh densities and solution time steps, and could not be directly correlated to the “calculation of record” to effectively demonstrate the ability of the shield building to withstand an aircraft impact. In response to these items, WEC issue IR 10-267-M026 to perform a mesh and time-step convergence study using the calculation of record. to demonstrate model stability and the ability of the shield building to withstand an aircraft impact.

4. Entrance and Exit Meetings

On May 23, 2011, the NRC inspection team discussed the scope of the inspection with Mr. Robert Sisk, as well as other representatives from WEC. On August 12, 2011, the NRC

inspection team presented the inspection results and observations during an exit meeting with WEC. Attachment 2 to this report lists the entrance and exit meeting attendees.

ATTACHMENT 1

1. PERSONS CONTACTED

Name	Company/Employer	Area
Winters, James	WEC	Passive Plant Technology
Accornero, Kevin F	WEC	NPE Engineering Operational Excellence
Arrigo, David	WEC	Global Quality Programs
Ray, Thomas	WEC	Licensing
Asztalos, Mike J	WEC	Technical Program Manager-Nuclear Systems
Cantarero Leal, Carlos	WEC	Structural and China Construction Support
Colflesh, John A	WEC	Continuous Improvement Systems
Corletti, Michael	WEC	Continuous Improvement Systems
Crittenden, Robert	WEC	Principal Quality Engineer, Quality Operations
Gerusky, Michael	WEC	Continuous Improvement Systems
Klaus, Paul J	WEC	NPP Corrective Action Dir
Monahan, Jill	WEC	Plant Analysis and Engineering Interface
Rice, William	WEC	Configuration Management
Shaw, Peter	WEC	Corrective Actions Manager
Wick, Paul	WEC	Nuclear Systems
Xenakis, Dee	WEC	Continuous Improvement Safety and Oversight
Ziesing, Rolj	WEC	Licensing

ATTACHMENT 2

1. MAY 23, 2011 - ENTRANCE MEETING ATTENDEES

Name	Company	Organization
Robert Prato	U.S. NRC	CQVA
Garrett Newman	U.S. NRC	CQVA
Tom Kendzia	U.S. NRC	CQVA
Bret Tegeler	U.S. NRC	DE
Jose Pires	U.S. NRC	RES
DeBlasio, John	WEC	Licensing
OCilka John	WEC	Licensing
Lindgren, Don	WEC	Licensing
Ritterbusch, Stan	WEC	Licensing
Coogler, Keith	WEC	Engineering
Watson, Jill	WEC	Engineering
Monaco, Carolyn	WEC	Quality & Continuous Improvement
Xenakis, Dee	WEC	Quality & Continuous Improvement
Prasad, Narendra	WEC	Engineering
Rudek, Terry	WEC	Engineering
Russ, Paul	WEC	International Licensing
Winters, Jim	WEC	Passive Plant Technology
Ray, Tom	WEC	Licensing
Harman, Dale	WEC	Quality Assurance
Tunon-Sanjux	WEC	Engineering
Corletti, Mike	WEC	Engineering
Filiak, Paul	WEC	International Licensing
Chari, Deva	WEC	Licensing
Rupparecht, Sandy	WEC	Licensing
Renaud, ED	WEC	Engineering
Brassarst, Gary	WEC	
Perez, Ricardo	WEC	

3. Inspection Procedures Used

Inspection Procedure 43002, "Routine Inspections of Nuclear Vendors"

4. List of Items Opened, Closed, and Discussed

The NRC has performed one previous inspections of the WEC AP1000 AIA.

The NRC found the following items during this inspection:

<u>Item Number</u>	<u>Status</u>	<u>Type</u>	<u>Description</u>
05200006/2011-202-1	Open	NOV	Criterion XVI, Appendix B to 10 CFR Part 50