November 9, 2012

Mr. Paul Russ, Director
AP1000 Licensing Programs
CWHQ-1 512B
1000 WEC Drive
Cranberry Township, PA 16066

SUBJECT: NUCLEAR REGULATORY COMMISSION VENDOR INSPECTION REPORT NO. 99900404/2012-202

Dear Mr. Russ:

From September 24 to 28, 2012, the U.S. Nuclear Regulatory Commission (NRC) conducted an inspection at the Westinghouse Electric Company (WEC) facility in Cranberry Township, PA. The purpose of the inspection was to review the corrective actions taken by WEC in response to several previous NRC identified inspection findings associated with the design and qualification testing of systems and components being supplied as part of the AP 1000 reactor design. As applicable, the inspection team reviewed aspects of your quality assurance program in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," and 10 CFR Part 21, "Reporting of Defects and Noncompliance." The enclosed report presents the results of this inspection. This NRC inspection report does not constitute NRC endorsement of your overall quality assurance (QA) and 10 CFR Part 21 programs.

During this inspection, the NRC inspection team determined that your corrective actions were sufficient to close out a number of the previously identified NRC inspection findings. However, the team was not able to close out two of the more important previously identified issues: (1) Nonconformance 99900404/2011-201-02 which concerned the evaluation of the impact of hydrodynamic forces resulting from inadvertent squib valve operation on piping and components; and (2) Open Item 99900404/201-201-05 which concerned the flow resistance calculation and consideration of check valve position for the refueling water storage tank injection lines. These two issues are also related to certain Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) contained in the AP 1000 Design Control Document, and as such, without appropriate resolution, may impact the ability of licensees to demonstrate specific ITAAC have been met. A table identifying each inspection finding reviewed by the team, its status, and the applicable ITAAC is contained at the end of the enclosed inspection report.

In accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding," of the NRC's "Rules of Practice," a copy of this letter, and its enclosures will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's

Agencywide Document Access and Manager System document system, accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

Sincerely,

/RA/

Richard A. Rasmussen, Chief
Electrical Vendor Branch
Division of Construction Inspection
and Operational Programs
Office of New Reactors

Docket No.: 99900404

Enclosure:
Inspection Report No. 99900404/2012-202
and attachment

Agencywide Document Access and Manager System document system, accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

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ADAMS ACCESSION No.: ML12313A461 NRC-001

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

Docket No.:	99900404
Report No.:	99900404/2012-202
Vendor:	Westinghouse Electric Company 1000 WEC Drive Cranberry Township, PA16066
Vendor Contact:	Mr. Ron Wessel, Principle Engineer 412-374-4023 wesselrp@WEC.com
Nuclear Industry Activity:	Westinghouse Electric Company (WEC) holds a design certificate for the AP1000 and is responsible for detailed design and testing for safety-related components to be used in AP1000 plants. These tests, including qualification and functional tests, are associated with and may directly impact closure of Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) from Revision 19 of the certified AP1000 design. Currently, these ITAAC are incorporated into the combined licenses of Vogtle Units 3 and 4 and V.C. Summer Units 2 and 3.
Inspection Dates:	September 24-28, 2012

Inspectors:	Jeffrey Jacobson	NRO/DCIP/CEVB	Team Leader
	Shavon Edmonds	NRO/DCIP/CEVB	
	Tuan Le	NRO/DE/EMB	
	Robert Mathis	R-II/DCI/CIB1	
	Dan Prelewicz	Contractor	

Approved:	Richard A. Rasmussen, Branch Chief Electrical Vendor Branch Division of Construction Inspection and Operational Programs Office of New Reactors

EXECUTIVE SUMMARY

The purpose of this inspection was to assess the adequacy of Westinghouse Electric Company's (WEC's) corrective actions to several Nuclear Regulatory Commission (NRC) inspection findings identified during two previous NRC inspections, Inspection Report Number 00000404/2011-201 and NRC Inspection 99900404/2012-201. These previous inspections focused on WEC's work associated with completing the AP 1000 detailed design and on specifying testing requirements for AP 1000 components. For each previous inspection finding, the team reviewed the adequacy of the corrective actions taken by WEC to address the specific technical issues identified, as well as the organizational and programmatic aspects associated with the issues.

During this inspection, the NRC inspection team determined that WEC corrective actions were sufficient to close out a number of the previously identified NRC inspection findings. However, the team was not able to close out two of the more important previously identified issues: (1) Nonconformance 99900404/2011-201-02 which concerned the evaluation of the impact of hydrodynamic forces resulting from inadvertent squib valve operation on piping and components; and (2) Open Item 99900404/201-201-05 which concerned the flow resistance calculation and consideration of check valve position for the refueling water storage tank injection lines. These two issues are also related to certain Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) contained in the AP 1000 Design Control Document, and as such, without appropriate resolution, may impact the ability of licensees to demonstrate specific ITAAC have been met.

With regard to Nonconformance 99900404/2011-201-02, the team determined that the analyses and calculations performed by Fauske & Associates to estimate the potential hydrodynamic loads that would occur under various squib valve operational scenarios were performed consistent with industry practices. However, the team raised concerns regarding how WEC was utilizing the resulting hydrodynamic load data in evaluating the impact on effected systems and components. Specifically, the WEC established acceptance criteria for the hydrodynamic loads, were developed with the assumption that the Probabilistic Risk Assessment case (600 psi initial pressure) and the spurious opening case at normal operation (2250 psi) of squib valve operation are beyond design basis events. The team determined that WEC has not provided sufficient justification for these events being beyond the design basis. This distinction is important as the criteria for assessing the impact of this event on piping and components is significantly different for design basis and beyond design basis events.

In addition, while WEC provided evidence that the analysis methodology used to calculate hydrodynamic loads was validated, none of the information provided was in the form of quality assurance documentation. The validation documentation was in the form of presentations, technical papers and informal reports that had not been included in the quality assurance documentation for the RELAP5 code. The team expressed similar concerns with the sensitivity studies that were performed to support the hydrodynamic loads analysis, with the input file for the APTPlot post processor, and with the equations developed to model the swing check valves in the RELAP5 analysis. Consequently, due to the above concerns the inspection team was unable to close out Nonconformance 99900404/2011-201-02.

The team also reviewed WEC corrective actions to Open Item 99900404/2011-201-05, which concerned the assumed position of the check valves in the In-Containment Refueling Water Storage Tank (IRWST) injection lines and their impact on the calculation of IRWST injection line flow resistance. The team determined that correct values for the resistance of partially open check valves are now being used in the WEC safety analyses; however, ITAAC Table 2.2.3-4, item 8.c requires verifying the proper flow resistance of each of the IRWST injection lines by measuring the water level (driving head) and discharge flow rate with the check valves in the full open position. WEC stated that they intend to remove this requirement from the ITAAC since the valve will not be in the full open position even when the tank is filled to the normal level.

In addition, the team determined that past experience has shown that extended operation of swing check valves in the partially open position can lead to failure of the check valve. WEC did not provide any evidence that acceptance criteria for extended operation of the IRWST and other Passive Core Cooling System check valves at partially open positions have been included in the design requirements. Consequently, Open Item 99900404/2011-201-05 will remain open pending submittal of a license amendment to resolve the ITAAC discrepancy described above and pending an update of the check valve qualification requirements.

Aside from the above two issues, the team was able to close out a number of the other issues reviewed, including:

- Nonconformance 99900404/2011-201-01 - Single Failure Vulnerability of Valve RNS-V023
- Nonconformance 99900404/2012-201-02 - Development of Interface Specifications for Squib Valve Field Run Cabling and Connectors
- Nonconformance 99900404/2012-201-03 - Lack Of Calculation To Demonstrate Acceptable Current Will Be Supplied To Squib Valves From The Diverse Actuation System (DAS)
- Open Item 99900404/2011-201-04 - Potential Spurious Actuation Of Squib Valves Due To Single Failure In DAS
- Open Item 99900404/2011-201-08 - Potential Common Cause Failures Due to Software in Electrical Distribution System
- Nonconformance 99900404/2012-201-05 - Use of Draft Purchase Specs to Develop Equipment Qualification Test Requirements
- Nonconformance 99900404/2012-201-04 - Errors in Limitorque Sizing Methodology

The team determined WEC corrective actions associated with the above issues were sufficient to consider the above issues closed. Also acceptable were the WEC corrective actions associated with the organization and programmatic aspects of the issues. A table identifying each inspection finding reviewed by the team, its status, and the applicable ITAAC is contained at the end of this report.

REPORT DETAILS

1. Background and General Scope

The purpose of this inspection was to assess the adequacy of Westinghouse Electric Company's (WEC) corrective actions to several Nuclear Regulatory Commission (NRC) inspection findings identified during two previous NRC inspections. The first group of corrective actions reviewed during this inspection derived from a previous NRC Engineering Design Verification Inspection (Inspection Report Number 00000404/2011-201). This inspection was performed during June and July of 2011, to assess the implementation of WEC's processes for completing the detailed design of the AP1000 reactor and for transferring the design requirements contained in the Design Control Document (DCD) into engineering, procurement, and construction documents. The second group of corrective actions reviewed derived from NRC Inspection 99900404/2012-201 performed in March of 2012. This inspection focused on the functional and type testing of components being supplied by WEC as part of the AP1000 certified reactor design. Such testing is required by NRC regulations to demonstrate that components that perform a safety function can be relied upon to operate throughout their qualified life after exposure to design basis accident conditions, including radiation, thermal aging, pressure, temperature, humidity, and seismic vibration, as applicable.

For each previous inspection finding, the team reviewed the adequacy of the corrective actions taken by WEC to address the specific technical issues identified, as well as the organizational and programmatic aspects associated with the issues. This included all corrective actions, extent of condition reviews, apparent cause evaluations, and root cause evaluations associated with the nonconformances and open items reviewed during the inspection.

Contained within this report is a synopsis of each of the original inspection findings, a summary of the corrective actions taken, an assessment with regard to the adequacy of the corrective actions, and a conclusion with regard to whether the inspection findings are considered to be closed or will remain open pending additional corrective actions.

2. Nonconformance 99900404/2011-201-02 - Effect of Squib Injection Valve Transient on In-Containment Refueling Water Storage Tank Check Valves and Related Components

a. Inspection Scope

In Inspection Report No. 99900404/2011-201, Nonconformance 99900404/2011-201-02 identified that the hydrodynamic forces generated by the inadvertent opening of the In-containment Refueling Water Storage Tank (IRWST) squib valves, combined with a relatively small volume between the IRWST squib valves and check valves, could result in stresses significantly in excess of the design limits for the associated piping, pipe supports, check valves, and related components. Significant issues identified by the team in Inspection Report No. 99900404/2011-201 included:

- WEC had not accounted for the hydrodynamic loads in the purchase specifications for piping and components in the IRWST injection line.

- WEC Open Item DI-OI-028536 which was written to evaluate the subject hydrodynamic loads, did not specify whether the analysis should be performed at the reduced reactor coolant system pressure that might be expected during a normal accident mitigation sequence, or at the much higher reactor coolant system pressure that might exist during inadvertent operation of the squib valves. Potentially large hydrodynamic forces could occur due to a spurious actuation of the IRWST squib valves while the reactor is at operating pressure.

- A documented process or procedure had not been implemented by WEC to ensure that once completed, the results of the transient analysis would be appropriately incorporated into the specifications and requirements for the related components.

WEC corrective actions to each of the issues identified above were assessed by the team to determine how each issue was categorized by the WEC corrective action program, the adequacy of any root cause analyses that were performed, and how WEC evaluated the extent of condition of the issues, as required by the WEC's quality assurance (QA) program and Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B.

During this inspection, the team also performed an in-depth review of calculations and analyses performed by Fauske & Associates (a Westinghouse subsidiary company) in response to the previous nonconformance. The calculations and analyses provide estimates of the expected transient hydrodynamic forces on the components located in-between the IRWST and the Direct Vessel Injection Line, including the check valves, PXS-V122A/B and PXS-V124A/B, located upstream of the squib valves.

The team reviewed the Fauske calculations: APP-PXS-M3C-073, "Analysis of Hydrodynamic Loads in the Response to DVI Squib Valve Actuation," and APP-PXS-M3C-074, "Beyond Design Basis Analysis of Hydrodynamic Loads in the AP1000 DVI System." These calculations documented transient hydrodynamic loads calculated by Fauske & Associates for spurious actuation of the squib valves in the IRWST injection line for three initial pressure conditions:

- 200 psig, the reactor coolant system pressure that might be expected during a normal accident mitigation sequence (Calculation APP-PXS-M3C-073)

- 600 psig, the reactor pressure corresponding to what WEC referred to as the Probabilistic Risk Assessment (PRA) case (Calculation APP-PXS-M3C-074), and

- 2250 psig, the normal reactor operating pressure (Calculation APP-PXS-M3C-074).

The team also reviewed the more programmatic corrective actions taken by WEC in response to the nonconformance.

b. <u>Findings and Observations</u>

Fauske & Associates used the RELAP5/MOD3.3 computer code to calculate the transient pressures, liquid and vapor velocities, void fraction and liquid and vapor densities resulting from spurious actuation of the squib valves. The APTPlot post processor was utilized to calculate the forces on each segment of the piping system from output of the RELAP5 calculation. The piping system modeled by RELAP5 included all piping and components between the reactor pressure vessel, the IRWST, the accumulator and the Core Makeup Tank (CMT). The codes used and the nodalization of the model were consistent with industry practice for analyzing hydrodynamic loads.

The squib valves are set to open following Automatic Depressurization System (ADS) - 4 actuation. There are two valves in parallel on each of the two injection lines. The opening sequence includes a 5 second delay on the second valve in each line. Analyses were performed with only one valve opening, and with the second valve opening with a 5 second delay in order to determine the bounding load. Fauske & Associates did not use the inertial check valve model that is a component in the RELAP5 code due to modeling limitations for their application and user trouble reports with this model. Rather, the check valve was modeled as a motor valve with the valve position calculated by use of RELAP5 control systems. This is a common practice for modeling swing check valves with RELAP5. Sensitivity calculations were performed to determine a conservative opening rate for the check valves located upstream of the squib valves. The structural analysis of the piping and system components was not completed at the time of this inspection and was not a subject of this review.

To validate use of the RELAP5 code for hydraulic loading analysis Fauske & Associates utilized several documents that contained comparisons of RELAP5 predictions to experimental data including:

- "Application of RELAP5 to Gas Water Flow Transients." This presentation compared RELAP5 calculations to experimental data from tests conducted by Fauske & Associates under Pressurized Water Reactor Owners Group sponsorship to support response to NRC Generic Letter 08-01. The inspectors reviewed the presentation and the report documenting the experiments, "Gas-Voids Pressure Pulsation Program." Waterhammer pressures and axial force imbalances were measured for insurge transients into a piping network with air trapped at a high point in the system. Tests were conducted with various high point pipe lengths and initial void fractions. The RELAP5 calculations compared well to the experimental data.

- The presentation cited above also showed comparisons of RELAP5 predictions to experimental data from "Experimental and analytical investigation of entrapped air in a horizontal pipe," by Lee and Martin, Proceedings of the Third ASME/JSME Joint Fluids Engineering Conference, San Francisco, July 18 - 23, 1999. RELAP5 calculations compared very well to the data for these waterhammer experiments.

- Comparison of RELAP5 predictions to Electric Power Research Institute (EPRI) sponsored experiments on hydrodynamic loading are documented in "Validation of a Thermal-Hydraulic Computer Code to Perform Two-Phase Multi-Component Force Calculations for Structural Evaluations," ICONE-13-50297. The experiments used in the validation are documented in "EPRI/CE PWR Safety and Relief Valve Test Program Summary." Comparisons were also made in the ICONE paper to tests run by Altran that were presented at the NURETH-11 conference. The EPRI tests have been widely used to qualify analytical techniques to calculate hydrodynamic loadings. Comparisons of RELAP5 calculations to the data from EPRI test CE 908 provided validation that the RELAP5 code as used by Fauske & Associates accurately predicts hydrodynamic loadings.

- Actuation tests of prototypical squib valves were conducted and documented in the WEC report APP-PV70-P1-001, "Squib Valve Actuation Load Analysis." Piping was connected to each end of the valve and pressurized to be representative of pressures expected at the time of actuation for a normal accident sequence. The test included introduction of air into the system as a result of the squib valve actuation. SPX Test 5 was simulated with RELAP5 for the first 25 msec after valve actuation. Fauske & Associates showed a plot of transient pressure response compared to RELAP5 calculations. RELAP5 conservatively predicted the peak pressure and the overall trend of the response. Forces were not measured in this test.

In aggregate, the team found the comparisons to test data provided validation of the RELAP5 code's ability to calculate hydrodynamic loads and pressure response. While the team determined that the method of calculating the expected hydrodynamic loads was acceptable, the team raised concerns regarding how WEC was utilizing the hydrodynamic load data in evaluating the impact on effected systems and components. Specifically, the WEC established acceptance criteria for the hydrodynamic loads, as documented in WEC calculation, APP-PXS-M3C-400, "Piping Hydrodynamic Loads Screening for Passive Core Cooling System (PXS)," are based upon the assumption that the PRA case (600 psi initial pressure) and the spurious opening case at normal operation (2250 psi) are beyond design basis events. The team determined that WEC has not provided sufficient justification for these events being beyond the design basis.

While unlikely, a spurious operation of the squib valves could be caused by a software failure in the PMS system, by unintended manual actions, or by other currently unquantifiable failure mechanisms. AP1000 DCD Paragraph 15.0.12.1 references NRC Commission Information Report SECY-77-439 "Single Failure Criterion", which states that, "Spurious activation of an active component is considered as an active failure for active components in safety-related passive systems. An exception is made for active components if specific design features or operating restrictions are provided that can preclude such failures (such as power lock out, confirmatory open signals, or continuous position alarms)." Contrary to the above, WEC is considering spurious operation of the 8" IRWST injection valves to be a beyond design basis event not subject to single failure requirements.

This position is also contrary to WEC's own assessment performed in response to issues raised associated with spurious operation of the 14" ADS squib valves. As stated in the WEC licensing position developed in response to Nustart Engineering Significant Issue 12, "WEC Licensing Position on NuStart Engineering Significant Issue 0012 – Squib Valve and Leak Before Break," dated November 10, 2011, the spurious opening of a squib valve would need to be considered an analyzed event or be shown to be an incredible event with an event frequency less that 1.0 E-06/yr.

To address the NuStart concern, as well as concerns raised by the NRC with the 14" squib valves, WEC installed an analog blocking contact in the squib valve firing circuit. This analog blocking circuit was only installed in the firing circuit for the 14" valves. A similar blocking circuit was not installed in the firing circuit for any of the 8" squib valves. With the addition of the blocking circuit WEC was able to show a combined failure rate of greater that 1 E-06/yr for the 14" valves.

Contrary to the analysis that was done for the 14" valves, the team identified that WEC is treating a spurious operation of the 8" IRWST squib valves as a beyond design basis event, even though they have not demonstrated that the spurious operation would be an incredible event with a stated failure probability of less than 1.0 E-06/yr. This distinction is important as the criteria for assessing the impact of this event on piping and components is significantly different for design basis and beyond design basis events.

In addition, while WEC provided evidence that the analysis methodology used to calculate hydrodynamic loads, .i.e. the RELAP5 and APTPlot (a RELAP5 post processor) computer codes, was validated, none of the information provided was in the form of quality assurance documentation. Fauske & Associates stated that the validation in their QA records consists of the sample cases provided with the RELAP5 code. The validation provided in the form of presentations, technical papers and informal reports has not been included in the quality assurance documentation for the RELAP5 code. The team expressed similar concerns with the sensitivity studies that were performed to support the hydrodynamic loads analysis and with the input file for the APTPlot post processor.

The team also reviewed APP-PXS-M3C-400, "Piping Hydrodynamic Loads Screening for Passive Core Cooling System (PXS)." This document was developed in response to the nonconformance in order to ensure that the calculated hydrodynamic loads are provided for in the structural analysis, and that the loadings are incorporated into design requirements. A new procedure, APP–GW–GAP–605, "AP1000 Hydrodynamic Loads Design Procedure," was also developed to document the process for determining hydrodynamic loads. The procedure specifically states that the hydrodynamic loads will be provided for structural analysis of both the piping integrity (hoop stress) and dynamic loading of the piping system and relevant components, and that requirements for hydrodynamic loadings will be included in the design specifications.

c. Conclusions

The team determined that the analyses and calculations performed by Fauske & Associates were consistent with industry practice for analyzing hydrodynamic loads. The team found the comparisons to test data provided validation of the RELAP5 code's ability to calculate hydrodynamic loads and pressure response. However, the team raised concerns regarding how WEC was utilizing the resulting hydrodynamic load data in evaluating the impact on effected systems and components. Specifically, the WEC established acceptance criteria for the hydrodynamic loads were developed with the assumption that the PRA case (600 psi initial pressure) and the spurious opening case at normal operation (2250 psi) of squib valve operation are beyond design basis events. The team determined that WEC has not provided sufficient justification for these events being beyond the design basis.

In addition, while WEC provided evidence that the analysis methodology used to calculate hydrodynamic loads was validated, none of the information provided was in the form of quality assurance documentation. The validation documentation was in the form of presentations, technical papers and informal reports that had not been included in the quality assurance documentation for the RELAP5 code. The team expressed similar concerns with the sensitivity studies that were performed to support the hydrodynamic loads analysis, with the input file for the APTPlot post processor, and with the equations developed to model the swing check valves in the RELAP5 analysis.

Consequently, due to the above concerns the inspection team was unable to close out Nonconformance 99900404/2011-201-02.

3. NRC Open Item 99900404/2011-201-05 - IRWST Injection Line Resistance

a. Inspection Scope

In NRC Inspection Report 99900404/2011-201, Open Item 99900404/2011-201-05 identified that the flow resistance in the IRWST injection line, as calculated by APP-PXS-M3C-019, was calculated assuming that check valves PXS-V122A/B and PXS-V124A/B in the IRWST injection lines would be fully open. However, the team identified that WEC had determined that these check valves will not be fully open, thus increasing the previously calculated flow resistance in this line. WEC concurred with this concern and stated that an internal review had also identified a similar concern and that Corrective Actions Process (CAP) Issue Report (IR) 11-076-C001 was tracking its resolution. WEC further indicated that their evaluation had determined that these check valves will not be fully open even with a full IRWST.

During this inspection, the team reviewed the WEC calculation APP-PXS-M3C-195, "Check Valve Functional Requirements for PXS IRWST Isolation Check Valves," which contained information from the valve vendor that can be used to determine flow resistance for partially open check valves similar to those in the IRWST injection line. The information from the vendor was translated into tables of flow resistance versus check valve position in WEC calculation APP-PXS-M3C-019, "IRWST/Containment Sump Injection Lines and ADS Line Resistances," which was also reviewed by the inspection team. The team verified that this open item is being tracked by CAP-IR-11-076-C001 and that a Root Cause Analysis (RCA), "Root Cause Analysis AP1000 Passive Core Cooling Test Issue", CAPs-RCA-11-076-001 was initiated and is underway at WEC. The team reviewed the documentation related to this CAP.

b. Findings and Observations

The team verified that WEC calculation APP-PXS-M3C-195 includes curves of the flow coefficient (C_v) versus disc position and velocity versus disc position. These are conservative curves based on generic eight inch check valves similar to those in the IRWST injection line. WEC stated that requirements to measure the flow coefficient for the prototypical check valves will be included in the purchase order for these check valves.

WEC used the valve vendor supplied curves in calculation APP-PXS-M3C-195 to develop tables of flow resistance as a function of valve disc position. The team verified that these tables are included in WEC calculation APP-PXS-M3C-019. The calculation also includes tables of flow resistance versus disc position for check valves in the containment sump injection lines and the ADS lines. WEC stated that these tables are used in safety analyses to model the flow resistances of the check valves, and that these tables will continue to be used unless the measured resistance for the prototypical valves is greater than provided by these curves. In this case new tables will be developed that bound the measured flow resistance for all valve positions.

The root cause analysis that was performed concluded that the problem was caused by a lack of rigor in the NSNP 3.4.1 process that allowed the initiator of a change to determine that a change only affects the initiator's organization and one other organization, thus bypassing review of potentially impacted organizations. The change that caused the check valves to be only partially open was modification of the velocity coefficient constant from 60 to 75 by the valve vendor because the coefficient of 60 could not be achieved with a swing check valve. Due to the low level of this change it was not required to enter it into the tracking system. The NSNP 3.4.1 process has since been revised so that no matter how many disciplines are affected, the changes are entered into the tracking system. The root cause analysis also addresses the extent of the condition that caused full open check valve resistance to be used in safety analyses for partially open check valves. The condition being evaluated is whether there are other safety-related check valves that may be partially open due to low flow rates without

properly accounting for the valve resistance. Since this may in turn affect safety-related performance assumptions, the RCA action plan includes a commitment to verify where other check valves may be partially open.
The proper flow resistance of each of the IRWST injection lines is verified by gravity draining water from the tank through the direct vessel injection flow path, while measuring the water level (driving head) and discharge flow rate using temporary instrumentation. This requirement is specified in ITAAC Table 2.2.3-4, item 8.c. The ITAAC currently specifies that the check valve be in the full open position during the test. WEC stated that they intend to remove this requirement from the ITAAC since the valve will not be in the full open position even when the tank is filled to the normal level. The flow resistance of a partially open valve provided in WEC calculation APP-PXS-M3C-019, Rev. 3 will be used in safety analyses.

c. <u>Conclusions</u>

WEC obtained information from the valve vendor that was used to conservatively bound flow resistance for partially open check valves in the IRWST injection line. This information was translated into tables of flow resistance versus check valve position for use in safety analyses. Correct values for the resistance of partially open check valves are now being used in safety analyses. To assure that changes are made to address the root cause that led to use of incorrect flow resistance for check valves, WEC conducted a RCA (CAPs-RCA-11-076-001, Rev. 1). The team concluded that the RCA has identified and remedied the situation that led to the problem of use of incorrect check valve flow resistance in safety-related analyses.

The current design specifications do not meet ITAAC Table 2.2.3-4, item 8.c as currently written because the ITAAC states that the check vales in the IRWST injection line must be fully open during the test. However, WEC previously identified that the check valve in the IRWST injection line will not be fully open even when the IRWST is at the normal level.

In addition, the team determined that past experience has shown that extended operation of swing check valves in the partially open position can lead to failure of the check valve. For example, IE Information Notice No. 86-09: Failure of Check and Stop Check Valves Subjected to Low Flow Conditions, February 3, 1986, reported that a facility experienced numerous failures of the 12 stop check valves in the steam supply system to the auxiliary feedwater pumps. The low flow rate was not sufficient to keep the disc open and the disc assembly then vibrated and chattered causing excessive wear and damage to the valve internals, in particular, the disc assembly. WEC did not provide any evidence that acceptance criteria for extended operation of the IRWST and other PXS check valves at partially open positions have been included in the design requirements. The team determined that WEC needs to incorporate these low flow conditions into the specifications for the check valves and that the qualification program needs to ensure that the valves can operate reliability under such extended low flow conditions.

Consequently, Open Item 99900404/2011-201-05 will remain open pending submittal of a license amendment to resolve the ITAAC discrepancy described above and pending an update of the check valve qualification requirements.

4. <u>Nonconformance 99900404/2011-201-01 - Single Failure Vulnerability of Valve RNS-V023</u>

a. <u>Inspection Scope</u>

In NRC Inspection Report 99900404/2011-201, Nonconformance 99900404/2011-201-01 identified a concern that a single valve arrangement for valve RNS-V023 could lead to the potential for an unanalyzed loss of coolant inventory from the Reactor Coolant System (RCS) into the IRWST should the valve be repositioned or spuriously open during Mode 4 of operation where the reactor is shutdown and the reactor coolant system is still at pressure. During that inspection, the NRC identified that the system design did not lock out power to this valve which is controlled from the Protection and Monitoring System (PMS). Additionally, unlike the control scheme for the Automatic Depressurization System (ADS) stage 4 valves, there is no diverse, non-software based interlock that would provide protection against a single failure from within the PMS system that could result in a spurious opening of the valve.

During this inspection, the NRC inspection team assessed the WEC corrective actions to the nonconformance including associated design change proposals, system specifications, and component requirements documents. The inspection team also reviewed the extent of condition analysis performed by WEC to identify the consequences of spurious actuation of active valves to determine whether additional design changes were warranted.

b. Findings and Observations

The inspection team reviewed Design Change Proposal (DCP) APP-GW-GEE-3133, "Procedural De-energizing of valve RNS-V023 during Operating Modes 4 and 5," which was developed by WEC to address the previously identified nonconformance. Valve RNS-V023 provides a safety function of containment isolation while also providing a path for IRWST gravity injection into the RCS during mid-loop. The single failure vulnerability occurs when the Normal Residual Heat Removal System (RNS) is aligned with the pressurized RCS. The DCP identified that the RNS is aligned with the RCS during Modes 4, 5, and 6 of operation and the RCS is pressurized during Mode 4 and partially during Mode 5. The condition of opening Valve RNS-V023 while the RNS is aligned with a pressurized RCS was determined to result in a loss of coolant inventory into the IRWST due to the RCS being at a higher pressure than the RNS. This loss of coolant inventory was also determined to potentially damage different components of the IRWST as well as the tank itself. The inspection team noted that Modes 1, 2, and 3 were not considered points of vulnerability even though the RCS is pressurized, due to the fact that the RNS will not be aligned with the RCS during these modes and spurious actuation of valve RNS-V023 would not impact containment isolation.

To address the above concerns, WEC implemented DCP APP-GW-GEE-3133 to physically lock-out valve RNS-V023 during Mode 4 and the pressurized part of Mode 5 of operation. Locking-out RNS-V023 was denoted by physically racking-out the breaker and locking-out the Motor Control Center. Doing so would inhibit spurious actuation of the valve by the PMS system while the RNS is aligned with the pressurized RCS. Consequently, valve RNS-V023 would be available outside of operation Modes 4 and 5 (pressurized). The inspection team also reviewed the documents affected by the approved design change to ensure that the appropriate documents were revised reflecting the change in design. The affected documents included APP-RNS-M3-001, "Normal Residual Heat Removal System – System Specification Document," and APP-RNS-M3C-100, "RNS Component Control Requirements," which will be used to develop procedures that will incorporate the design change to lock-out valve RNS-V023 during operation Modes 4 and 5.

The inspection team also reviewed the extent of condition analysis, DCP-DCP-003044, "Spurious Actuation of Valves Assessment," which was performed by WEC assess the consequences of a spurious actuation of all active valves. The inspection team noted that the extent of condition analysis did not identify any additional valves that were vulnerable to a single failure similar to valve RNS-V023.

c. Conclusions

The inspection team determined that the corrective actions taken by WEC to address the design vulnerabilities associated with valve RNS-V023 were adequate. The inspection team also determined that the extent of condition review performed by WEC to identify other valves that might be susceptible to a similar single failure vulnerability was also adequate. Based on the results of this inspection, NON 99900404/2011-201-01 is closed. No other findings of significance were identified.

5. Nonconformance 99900404/2012-201-02 - Development of Interface Specifications for Squib Valve Field Run Cabling and Connectors

a. Inspection Scope

In NRC Inspection Report 99900404/2012-201, Nonconformance 99900404/2012-201-02 identified that APP-GW-J4-072, "Interface Specification for Squib Valve Controller," did not provide sufficient information to allow for the proper sizing of the squib valve firing circuit cabling, as it did not include the full range of temperatures that needed to be considered when sizing the cables. While the interface specification alluded to the fact that the cabling resistances need to be verified and accident conditions need to be considered when designing the field cabling system, the specification stated that it was the responsibility of the cable designer to meet the resistance requirements of the system.

During this inspection, the inspection team reviewed IR#12-102-C007, "PMS Temperature Conditions," and interviewed WEC personnel to review WEC corrective actions to the identified nonconformance. The inspection team also reviewed cable and raceway documentation to verify that appropriate separation and segregation measures are designated for future squib valve field cable installation.

b. Findings and Observations

The inspection team noted that Issue Report (IR) #12-102-C007 implemented corrective actions including revising APP-GW-J4-072, "Interface Specification for Squib Valve Controller," to clarify that cable resistances should be calculated based on worst case temperature conditions. The inspection team reviewed and observed that the squib valve interface specification requirement R2.2.3-4 states that the round-trip resistance of the field wiring between the PMS termination unit output and the initiator shall be a maximum of 3 ohms, including all connections and penetrations, and excluding the resistance of the initiator. This requirement was revised to add the stipulation that the maximum field wiring resistance shall be calculated at worst case conditions, including Design Basis Accident (DBA) environmental conditions inside containment as defined in Appendix B of APP-GW-VP-010, "Equipment Qualification Methodology and Documentation Requirements for AP1000 Safety-Related Valves and Valve Appurtenances."

During the review of APP-GW-VP-010, the inspection team noted that Appendix B identifies the environmental conditions for containment during a DBA, which represents the worst case conditions for squib valve actuation. The worst case temperature was identified as 422 deg F.

The inspection team also reviewed APP-EW21-E1-001, "AP1000 Standard Raceway and Cable Separation and Segregation," and noted that Table 2.1-2 specifies that squib igniter circuit cables shall be separated from all cables connected to a power source that is capable of delivering a fault current that is greater than the specified "No Fire" current of the squib (nominally 1 amp). This standard also denoted that acceptable means of separation include conduits and grounded metal barriers in specified raceways.

c. Conclusions

The inspection team determined that corrective actions taken by WEC to revise the interface specification for squib valve controllers, APP-GW-J4-072, were adequate. The interface specification now states that resistance calculations for the firing circuit cabling should be performed assuming worst case conditions. The specification also now provides appropriate references to the input parameters necessary to perform the calculation. The inspection team also determined that suitable measures were specified for cable separation and segregation of squib valve igniter circuits. Based on this inspection, NON 99900404/2012-201-02 is closed. No other findings of significance were identified.

6. Nonconformance 99900404/2012-201-03 - Lack Of Calculation To Demonstrate Acceptable Current Will Be Supplied To Squib Valves From The Diverse Actuation System (DAS)

a. Inspection Scope

In NRC Inspection Report 99900404/2012-201, Nonconformance 99900404/2012-201-03 identified that there was no documented design analysis to support the required DAS resistance values for field cabling and connectors to the squib valve circuitry.

During this inspection, the inspection team reviewed corrective actions taken by WEC in response to the nonconformance as documented in IR #12-102-M047, "Design Calculation for DAS Squib Valve Actuation Circuit." The team also reviewed documents and interviewed WEC personnel to ensure that a documented design analysis was performed to ensure the DAS Squib Valve Controller (SVC) would be capable of providing the necessary current to fire the squib valves, assuming maximum circuit resistance to the squib igniter under all operating conditions. Lastly, the inspection team reviewed cable and raceway documentation to verify that appropriate separation and segregation measures were designated for squib valve field cable installation.

b. Observations and Findings

The inspection team reviewed IR #12-102-M047 which directed corrective actions to perform a design calculation to validate the electrical requirements of the DAS circuit. The calculation covered the circuit from the processor cabinet to the valve initiator for all possible actuation environmental conditions. The design calculation was documented in APP-DAS-J4-002, "AP1000 Diverse Actuation System Squib Valve Controller Design Specification." The inspection team reviewed this design specification and found that it contained the appropriate electrical requirements for the DAS SVC, including the minimum firing current of 3.7 Amps (A) applied for at least 0.01 seconds across a maximum resistance of 4.1 ohms. The DAS SVC was also specified to incorporate de-bounce logic for the "actuate" input signal with a bounce delay of at least 10 milliseconds to reduce the likelihood of an inadvertent actuation due to contact chatter.

The analysis took into account the total resistances of all cabling and connections within the DAS processor cabinet, the total resistance across relay contacts, the resistances and voltage drop of the components in the SVC, the total resistances of the field cabling and connections to the squib valve igniter, and the resistance of the squib valve igniter bridgewire. The assumptions utilized for the analysis included the 24 volts direct-current (VDC) power supply operating at the lowest end of its tolerance band, maximum resistance contribution from the devices in the DAS processor cabinet, maximum resistances and voltage drop across the components in the SVC, and the anticipated worst case environmental conditions. The result of the analysis calculated that the expected minimum current to be supplied to the squib valve by the DAS would be 4.6A. With a minimum requirement of 3.7A for the squib valve igniter, a 24% margin was calculated to be available.

The inspection team also reviewed APP-EW21-E1-001, "AP1000 Standard Raceway and Cable Separation and Segregation," and noted that Table 2.1-2 specifies that squib igniter circuit cables shall be separated from all other cables connected to a power source that is capable of delivering a fault current that is greater than the specified "No Fire" current of the squib (nominally 1A). This standard also denoted that acceptable means of separation include conduits and grounded metal barriers in specified raceways.

c. Conclusions

The inspection team determined that the corrective actions taken by WEC in response to the nonconformance were acceptable. The inspection team also determined that suitable measures were specified in relation to cable separation and segregation of squib valve igniter circuits. Based on the results of this inspection, NON 99900404/2012-201-03 is closed. No other findings of significance were identified.

7. Open Item 99900404/2012-201-04 - Potential Spurious Actuation Of Squib Valves Due To Single Failure In Diverse Actuation System (DAS)

a. Inspection Scope

In NRC Inspection Report 99900404/2012-201, Open Item 99900404/2012-201-04 identified a concern regarding the potential for a seismic event to cause the simultaneous unintended actuation of two independent controllers in the DAS system that could then result in the spurious actuation of the Stage 4 ADS squib valves. To resolve this open item, WEC provided the team copies of test procedures and the qualification summary report for the electromagnetic compatibility (EMC), equipment qualification (EQ) and seismic testing of the squib valve controllers in the DAS system. In addition, the NRC inspection team conducted several interviews of WEC's management and technical staff about the evaluation process of all design testing performed in response to this open item.

b. Observations and Findings

The NRC inspection team verified that WEC performed seismic testing to verify that a seismic event would not result in the in advertent actuation of the squib valve controllers. WEC used APP-GW-GEP-010 "Process & Procedure for AP1000 Internal Open Items and holds," to track all of the test plans, procedures, and summary reports for all testing conducted on the squib valve controllers. The NRC Inspection team reviewed the updated design and functional requirements of the DAS system and all testing and design documents that demonstrated the qualification of the system. These documents included qualification summary reports for the EMC, EQ, and seismic testing of the squib valve controllers which are located in the DAS system cabinets. The EMC qualification summary report documented that the test was conducted for all internal equipment and structural cabinet portions of the DAS equipment. The NRC inspection team verified that all associated design and seismic testing of the squib valve controllers was performed according to WEC's Quality Manual System (QMS) which details the controls established to ensure applicable technical and quality requirements were met.

c. Conclusions

Based on the documents reviewed, the NRC inspection team determined that Open Item 99900404/2011-201-04 can be closed. No other findings of significance were identified.

8. Open Item 99900404/2011-201-08 - Potential Common Cause Failures Due to Software in Electrical Distribution System

a. Inspection Scope

In NRC Inspection Report 99900404/2011-201, Open Item 99900404/2011-201-08 identified that WEC had not taken actions to ensure that software being utilized in the Class 1E Direct Current and Uninterruptable Power Systems (UPS) would be properly validated and verified. During this inspection, the NRC inspection team reviewed revised WEC documents that contained the software verification and validation requirements. The team also reviewed implementing purchase orders that were utilized to pass down these requirements from WEC to the equipment manufacturers.

b. Findings and Observations

In response to the previous open item WEC developed APP-GW-GLR-152," Software Qualification Plan for AP 1000 S and UPS System (IDS)." This document details WEC's plan for validating and verifying the software/firmware contained within the IDS system. The qualification was written to conform with NRC requirements, including the assessment of diversity and defense in depth, as necessary to prevent common cause failures. The plan requires suppliers to supply software validation & verification packages, history documentation, failure rates for each component, and a design strategy document. The inspection team verified that WEC passed down these requirements to its sub-vendor through Purchase Order (PO) 4500426010, "AP1000 Purchase Order for Class 1E Battery Chargers, Regulating Transformers and Inverters, Vogtle Units 3 & 4." The PO contained detailed software requirements including requirements for evaluating potential common cause failures in software logic. The team also conducted several interviews with WEC management and technical staff regarding the software verification and validation process.

c. Conclusions

Based on the documents reviewed, the team determined that WEC had taken corrective actions sufficient to close out Open Item 99900404/2011-201-08. No other findings of significance were identified.

9. Nonconformance 99900404/2012-201-05 - Use of Draft Purchase Specs to Develop EQ Test Requirements

a. Inspection Scope

In Inspection Report 99900404/2012-201, Nonconformance 99900404/2012-201-05 identified that WEC had not appropriately incorporated into the test plan a change to the design specification for the motor actuator components. The NRC inspection team reviewed the AP1000 design specification for the electric motor actuators and the design procedures for the actuator test specimens. In addition, the NRC inspection team thoroughly reviewed the Limitorque sizing methodology documentation and associated extent of condition reviews performed by WEC in response to the nonconformance.

b. Findings and Observations

In response to the nonconformance, WEC performed a reconciliation evaluation between APP-PV95-Z0-001, "Equipment Design Requirements for Safety-Related Limitorque Motor Actuator Test Specimen" Rev 2, dated July 2012 and its latest revision. WEC also conducted a review of NSNP 3.4.1, "Change Control Process for the AP 1000 Program," to ensure that all documents affected by the design change proposal process are tracked and that appropriate changes are incorporated into the documents once approved. The team also reviewed the WEC extent of condition review performed in response to the nonconformance. The extent of condition review determined that the use of design draft documents was an isolated case.

c. Conclusions

Based upon the above review, the team determined that the WEC corrective actions to Nonconformance 99900404/2012-201-05 were adequate and that the nonconformance can be closed. No other findings of significance were identified.

10. Nonconformance 99900404/2012-201-04 - Errors in Limitorque Sizing Methodology

a. Scope

In Inspection Report 99900404/2012-201, Nonconformance 99900404/2012-201-04 identified that WEC had failed to perform an acceptance review of an analysis performed by Limitorque to group actuators for the purpose of qualification testing. During this inspection, the team reviewed WEC's corrective actions to the nonconformance, including their revision to the sizing methodology document.

b. Findings and Observations

The team identified that WEC had acceptably revised the sizing methodology document to reflect the correct selection of actuators to be tested. WEC also requested Limitorque to revise the document to follow the selection methodology detailed in IEEE STD 382-1996. The team verified through corrective action reports that WEC had implemented appropriate corrective actions, including revising the sizing methodology document and completing an extent of condition review to ensure this was an isolated occurrence.

c. Conclusions

Based upon the above review, the team determined that the WEC corrective actions to Nonconformance 99900404/2012-201-04 were adequate and that the nonconformance can be closed. No other findings of significance were identified.

11. Nonconformance 99900404/2011-201-03 – Improper Use of Sum of the Squares Methodolgy In Combining Structural Forces

a. Scope

In Inspection Report 99900404/2011-201, Nonconformance 99900404/2011-201-03 identified the method used by Westinghouse to combine the high frequency and low frequency periodic and rigid seismic responses of the containment internal structures was contrary to the method specified in the DCD. In paragraph 3.7.3.7.1.2, the DCD states, "The total combined response to high-frequency modes (Step 3) is combined by the square root of sum of the squares method with the total combined response from lower-frequency modes (Step 1) to determine the overall structural peak responses." This information is classified in the DCD as Tier 2* information that requires approval from the NRC prior to implementing a change to the methodology. Contrary to the above, in calculation APP-1100-S2C-002, "Response Spectrum Analysis of AP1000 Containment Internal Structures", Westinghouse used an alternate direct algebraic summation method to combine the periodic and rigid seismic responses of the CIS.

b. Findings and Observations

In response to the nonconformance, WEC revised calculation APP-1100-S2C-002 (Revision 7) to perform the subject analysis using the square root sum of the squares methodology that was described in the DCD. The team reviewed the calculation and verified that applicable terms were now being combined using the appropriate methodology.

C. Conclusions

Based upon the above review, the team determined that the WEC corrective actions to Nonconformance 99900404/2011-201-03 were adequate and that the nonconformance can be closed. No other findings of significance were identified.

12. Table of Items Opened/Closed and associated ITAAC

Nonconformance/Open Item Number	Open/Closed	Related ITAAC
99900404/2011-201-01	Closed	N/A
99900404/2011-201-02	Remains Open	Table 2-2-3-4, Items 2.a) and 2.b) of AP1000 DCD
99900404/2011-201-03	Closed	N/A
99900404/2011-201-04	Closed	N/A
99900404/2011-201-05	Remains Open	Table 2-2-3-4, Item 8c of AP1000 DCD
99900404/2011-201-08	Closed	N/A
99900404/2012-201-02	Closed	Table 2.2.3.4, Item 7.a).ii) of AP1000 DCD
99900404/2012-201-03	Closed	Table 2.2.3.4, Item 7.a).ii) of AP1000 DCD
99900404/2012-201-04	Closed	N/A
99900404/2012-201-05	Closed	N/A

ATTACHMENT

1. Exit Meeting

On September 28, 2012, the NRC inspection team conducted an exit meeting with WEC management and staff and discussed the results of the inspection. The following people were contacted during the inspection. Those that attended the exit meeting are so indicated.

NAME	TITLE	ORGANIZATION	X
Anthony Trupiano	Principle Engineer Nuclear Systems	WEC – NS	X
Bill Rice	Director - US Equipment and Systems	WEC – NS	X
Bob Hirmanpour	ITAAC	Southern	X
Brian Schleger	Project Manager - EQ	WEC – NA	X
Charles Pierce	Licensing	Southern	X
Chris Henry	Engineer	Fauske and Associates	X
Chris Ware	Manager - Nuclear Systems	WEC – NS	X
Chuck Brockhoff	Principle Engineer System Design	WEC – NS	X
David Arrigo	Manager - Quality Programs	WEC Global Quality	X
George Roberts	Principle Engineer - EQ	WEC - NA	X
Greg Cesare	Engineer - Plant Integration	WEC – NS	X
Jaehyok Lim	Engineer	Fauske and Associates	X
Jason Brehm	Project Manager - V.C. Summer 2&3	WEC - NPP	X
Jim Bloom	Engineer - EQ	WEC – NA	X
John Papai	Quality Engineer	WEC Global Quality	X
Julie Ezell	Licensing	SCANA	X
Kyra Durinsky		WEC	
L. Mulhollem	Auxiliary Equipment Engineer	WEC	
Laura Goossen	Program Manager - EQ	WEC – NPP	X
Luca Oriani	Acting Director - AP1000 Piping	WEC - NS	X

NAME	TITLE	ORGANIZATION	X
Mark Fetting	Program Manager - Squib Valves	WEC - NPP	X
Mark Wilson	Licensing	Southern	X
Melita Osborne	Director - EQ	WEC - NA	X
Mike Corletti	Director - Technical Projects Integration	WEC - NS	X
Mike Wilkie	Acting Director - China Engineering	WEC – NS	X
Preston Vock	Manager - Valve Engineering	WEC - NS	X
Ricardo Llovet	E&P Director - Vogtle 3&4 Projects	WEC - NPP	X
Richard Delong	Acting Director - New Plant Licensing	WEC - NPP	X
Ronald Wessel	Principle Engineer- AP1000 Licensing	WEC - NPP	X
Ryan Burda	Engineer - Nuclear Engineer	WEC – NS	X
Ryder Thompson	Licensing	SCANA	X
Stan Thomason	Licensing	Southern	X
T. Trulick	RNS System Engineer	WEC	
Tim Drouin	Director - Plant Integration	WEC - NPP	X

2. INSPECTION PROCEDURES USED

IP 43002, “Routine Vendor Inspection”
IP 36100, “Inspection of 10 CFR Part 21 and Programs for Reporting Defects and Noncompliance”
P 65001.E, “Inspection of the ITAAC-Related Qualification Program,”
IP 35034, “Design Certification Testing Inspection”

3. DOCUMENTS REVIEWED

APP-PXS-M3C-400, "Piping Hydrodynamic Loads Screening for Passive Core Cooling System (PXS)", Rev. 1

APP – GW – GAP – 605, “AP1000 Hydrodynamic Loads Design Procedure” Rev. 0

APP-GW-GEE-3141, Rev. 0 “AP1000 Design Change Proposal”

APP-PXS-M3C-073, “Analysis of Hydrodynamic Loads in the Response to DVI Squib Valve Actuation”, by Jaehyok Lim and Christopher Henry, June 13, 2012

APP-PXS-M3C-074, “Beyond Design Basis Analysis of Hydrodynamic Loads in the AP1000 DVI System”, by Jaehyok Lim, June 22, 2012.

APP-PV70-P1-001, "Squib Valve Actuation Load Analysis", Rev. 0, 2011.

APP-PXS-M3C-075, "CMT Nozzle Check Valve Analysis in Response to Large Break LOCA", Rev. 0

APP-PXS-M3C-019, "IRWST / Containment Sump Injection Lines and ADS Line Resistances", Rev. 3, November 17, 2011

APP-PXS-M3C-195, “Check Valve Functional Requirements for PXS IRWST Isolation Check Valves” Rev. 2, October 25, 2011.

APP-DC01-VFX-001, “AP 1000 DC01 Class 1E Battery Charger Released Document List”, Revision 0, dated Mar 27, 2012

APP-PV95-VP-001,“Equipment Design Requirements for Safety-Related Limitorque Motor Actuator Test Specimens”, Revision 2, dated July 2012

APP-GW-GEP-010, Process & Procedure for AP1000 Internal Open Items and holds, Revision 5, dated Aug 29, 2011

APP-GW-GLR-152,”Software Qualification Plan for AP 1000 S and UPS System (IDS)”, Revision 1, dated January 2012

APP-DAS-VPP-001, “AP1000 EMC Test Procedure for the Diverse Actuation System (DAS)”, Revision 0, dated January 2012

APP-DAS-VPP-002, “AP1000 Seismic Test Procedure for the Diverse Actuation System (DAS)”, Revision 0, August 2012

APP-DAS-VBR-000, AP1000 Diverse Actuation System Equipment Qualification Summary (DAS Cabinets), Revision 0, September 2012

APP-DAS-J1-001, AP1000 Diverse Actuation System Functional Requirements, Revision 3, August 2012

APP-RNS-M3-001, Normal Residual Heat Removal System – System Specification Document, Rev. 2

APP-RNS-M3C-100, RNS Component Control Requirements, Rev. 7

APP-GW-J4-072, Interface Specification for Squib Valve Controller, Rev. 1

WNA-CN-00206-GEN, PMS Squib Valve System Operating Parameters, Rev. 3

APP-GW-VP-010, Equipment Qualification Methodology and Documentation Requirements for AP1000 Safety-Related Valves and Valve Appurtenances, Rev. 2

APP-EW21-E1-001, AP1000 Standard Raceway and Cable Separation and Segregation, Rev. 1

APP-DAS-J4-002, AP1000 Diverse Actuation System Squib Valve Controller Design Specification, Rev. 0

APP-GW-GEE-3133, Procedural De-energizing of RNS Valve V023 during Operating Modes 4 and 5, Rev. 0

DCP_NRC_003194, Reply to Notice of Nonconformances Cited in NRC Inspection Report No. 99900404/2011-201 dated September 27, 2011

DCP-DCP-003044, Spurious Actuation of Valves Assessment, Dated 12/15/2011

DCP_NRC_003218, Reply to Notice of Nonconformances Cited in NRC Inspection Report No. 99900404/2012-201 dated May 17, 2012

"Application of RELAP5 to Gas Water Flow Transients", presentation by Kevin Ramsden at NEI Meeting, Dana Point, CA, February 11, 2009.

"Gas-Voids Pressure Pulsation Program", R. E. Henry, J. Conzen, K. Ramsden, D. Stepanczyk and K. Dhanji, FAI/08-70, Rev. 1, September 3, 2008.

"Validation of a Thermal-Hydraulic Computer Code to Perform Two-Phase Multi-Component Force Calculations for Structural Evaluations" by J. S. Miller and K. Ramsden, ICONE-13-50297, Beijing, China, May 16-20, 2005.

Corrective Action Program Report CAPs-RCA-11-076-001, Rev. 1"Valve Review to ITAAC Requirements"

Design Control Document (DCD) Tier 1, ITAAC Table 2.2.3-4, item 8.c

IE Information Notice No. 86-09: Failure of Check and Stop Check Valves Subjected to Low Flow Conditions, February 3, 1986.

Nustart Engineering Significant Issue 12, "WEC Licensing Position on NuStart Engineering Significant Issue 0012 – Squib Valve and Leak Before Break," dated November 10, 2011

PO 4500426010, " AP1000 Purchase Order for Class 1E Battery Chargers, Regulating Transformers and Inverters, Vogtle Units 3 & 4", Rev 0, dated Feb 21, 2012

WEC 3.3.1, "Design Reviews", Revision 3, dated Nov 1st 2011

WEC 21.0, "Identification and reporting of conditions adverse to nuclear safety", Revision 7.1 (no date)

WEC 16.2, Westinghouse Corrective Action Process , Revision 4.1, dated April 17, 2012

QMS, "Westinghouse Quality Management System Level 1 Procedure", Revision 6, August 13, 2010

Corrective Action Report # 12-089-M020, "Errors in Limitorque sizing methodology", dated Oct 21 2012

Corrective Action Report # 12-089-M043, "Use of draft Limitorque purchase specs to develop EQ test requirements", dated Oct 21 2012

Corrective Action Report # 11-188-M045, "Extent of condition NON 2011-201-03 SRSS method", dated 07/07/2011

Corrective Action Report # 11-209-M002, "Determine extent of condition associated with the spurious actuation of valves from both the PMS and the DAS", dated 07/28/2011

Corrective Action Report # 11-209-M002.01, "Perform Extended condition review of valves actuated by PMS and DAS", dated Aug 31, 2011

Corrective Action Report # 11-196-M006,"Potential RNS V023 Valve Logic Control Deficiency", dated (not sure)

Corrective Action Report # 11-076-C001,“Root Cause Analysis of Open Item Flow resistance for IRWST injection line”, dated (not sure)

Issue Report (IR) # 12-102-C007, PMS Temperature Conditions, dated 6/3/2012

Issue Report (IR) 12-102-M047, Design Calculation for DAS Squib Valve Actuation Circuit, Dated 8/26/2012

APP-1100-S2C-002, “Response Spectrum Analyses of AP 1000 Internal Structures,” Revision 7

4. LIST OF ACRONYMS USED

10CFR	Title 10 of the Code of Federal Regulations
A	Amps
ADS	Automatic Depressurization System
ASME	American Society of Mechanical Engineers
CAPs	Corrective Actions Process
CMT	Core Makeup Tank
DAS	Diverse Actuation System
DBA	design basis accident
DCD	Design Control Document
DCP	Design Change Proposal
Deg F	Degrees Fahrenheit
EDV	Engineering Design Verification
EPRI	Electric Power Research Institute
EQ	Equipment Qualification
IP	Inspection Procedure
IR	Issue Report
IRWST	In-Containment Refueling Water Storage Tank
ITAAC	Inspections, Tests, Analyses and Acceptance Criteria
JSME	Japan Society of Mechanical Engineers
LOCA	loss of coolant accident
MCC	Motor Control Center
NEI	Nuclear Energy Institute
NON	Notice of Nonconformance
NRC	U. S. Nuclear Regulatory Commission
P&ID	Piping and Instrumentation Diagram
PMS	Protection and Safety Monitoring System
PRA	Probabilistic Risk Assessment
PWROG	Pressurized Water Reactor Owners Group
PXS	Passive Core Cooling System
QA	Quality Assurance
RCA	Root Cause Analysis
RCS	Reactor Coolant System
RNS	Normal Residual Heat Removal System
SVC	Squib Valve Controller
VDC	Volts Direct-Current
WEC	WEC Electric Company