December 30, 2008

Mr. Rob Sisk
Manager AP1000 Licensing and Customer Interface
Westinghouse Nuclear Power Plants
Energy Center
4350 Northern Pike
Monroeville, PA 15146

SUBJECT: SUMMARY OF THE OCTOBER 13 - 17, 2008, ON-SITE REVIEW OF THE AP1000 COMPONENT DESIGN

Dear Mr. Sisk:

Enclosure 1 contains the NRC's trip report for the on site review of the AP1000 component design. During October 13 - 17, 2008, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an on-site review of the AP1000 component design based on the requirements of Standard Review Plan (SRP) 3.9.3. The purpose of the on-site review was to verify that the AP1000 component design was in accordance with the methodology and design criteria described in the Design Control Document (DCD). Specifically, Section 7 of Appendix A to SRP Section 3.9.3 provides guidance that the staff may request the submission of the Code-required Design Documents (such as Design Specifications, Design Reports, Load Capacity Data Sheets, and other related material or portion thereof), in order to establish that the design criteria, analytical methods, and functional capability satisfy the guidance provided by the SRP Section 3.9.3. This includes verification that the design information described in the DCD was adequately translated into documentation for each of the components designed to the American Society of Mechanical Engineers (ASME) Code Section III, Class 1, 2, and 3 requirements.

Some issues and questions were raised by the staff, and a total of seven open items remained to be answered at the end of the on-site review. These open items will be addressed by the NRC through requests for additional information (RAI). The list of RAIs is provided in Enclosure 2. Once all the above mentioned RAIs are satisfactorily resolved by Westinghouse, a safety evaluation report can be written to close out the Combined License Action Item 3.9.2.4-1 identified in the AP1000 Final Safety Evaluation Report.

If you have any question regarding this matter, I may be reached at 301-415-5848.

Sincerely,

/RA/

William C. Gleaves, Sr Project Manager
AP1000 Projects Branch 2
Division of New Reactor Licensing
Office of New Reactors

Docket No. 52-006
Enclosure:
As stated

cc w/encl: See next page

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SUMMARY OF THE OCTOBER 13 TO 17, 2008, ON-SITE REVIEW OF THE AP1000 COMPONENT DESIGN

During October 13 to 17, 2008, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an on-site review of the AP1000 component design based on the requirements of Standard Review Plan (SRP) 3.9.3. The purpose of the on-site review was to verify that the AP1000 component design was in accordance with the methodology and design criteria described in the Design Control Document (DCD). Specifically, Section 7 of Appendix A to SRP Section 3.9.3 provides guidance that the staff may request the submission of the Code-required Design Documents (such as Design Specifications, Design Reports, Load Capacity Data Sheets, or other related material or portion thereof), in order to establish that the design criteria, and analytical methods, and functional capability satisfy the guidance provided by the SRP Section 3.9.3. This includes verification that the design information described in the DCD was adequately translated into documentation for each of the components designed to ASME Code Section III, Class 1, 2, and 3 requirements.

Westinghouse had provided a list of major mechanical components for which the certified design specifications and design reports would be completed and available for the NRC audit. These include the: reactor vessel, reactor vessel internals, control rod drive system, steam generator, pressurizer, passive residual heat remover, heat exchanger, core makeup tank, and accumulator. Westinghouse had indicated that auxiliary equipment and valves are procured from third party suppliers. These components typically do not have a design review or a design report prior to procurement. The staff decided to review the certified design specifications of the valves to ensure that the design specifications contain sufficient information to the extent that they are ready for procurement, in accordance with 10 CFR 52.47. Three valves were selected for the review. They included motor operated globe and gate valves, solenoid valves, and air operated globe valves. In addition, in the interest of Generic Safety Issue - 191, the design specification for the containment recirculation screens was also selected for review.

It should be noted that the core makeup tank and accumulator were reviewed a second time. During the previous on-site review conducted for these two components, in December 2006, the staff found that the design specifications and design reports were adequately documented in accordance with ASME Code Section III requirements. The staff noted, however, that the designs did not reflect the final AP1000 design seismic ground motions specified in DCD, and that a second review would be conducted, if required. A large number of design documents were reviewed at the site. The list is provided in the attachment.

Based on the information reviewed, the staff found that the design documents for all the reviewed components, including the core makeup tank and accumulator, reflected the methodology and criteria contained in the DCD, and met the requirements of ASME Code, Section III, Article NCA-3000. Some issues and questions were raised by the staff, and a total of seven open items remained to be answered at the end of the on-site review. These open items will be addressed by the NRC through requests for additional information (RAI). The list of RAIs is provided in Enclosure 2. Once all the above mentioned RAIs are satisfactorily resolved by Westinghouse, a safety evaluation report can be written to close out the Combined License Action Item 3.9.2.4-1 identified in the AP1000 Final Safety Evaluation Report.

Documents Reviewed at the October 13 to 17, 2008 AP1000 Components On-Site Review

Reactor Vessel

APP-MV01-Z0-101, AP1000 Reactor Vessel Design Specification, Revision 2, 144 pages, September 12, 2008

APP-SS30-Z0-001, RCS Primary Equipment Supports Design Specification, Revision 0, 42 pages, July 30, 2008

APP-MV01-Z0R-101, AP1000 Reactor Vessel ASME Code Design Report, Revision 2, 142 pages, October 3, 2008

APP-MV01-Z0C-016, Detailed and Transient Analysis of Lower Shell and Lower Head Regions for AP1000 Reactor Pressure Vessel (RPV), Revision 2, 76 pages, Electronically Approved

APP-MV01-Z0C-075, AP1000 RV Head Penetration Primary Stress Evaluation, Revision 0, 62 pages, Electronically Approved

APP-MV01-Z0C-015, Detailed Analysis of Closure Head and Vessel Flange Region for AP1000 Reactor Pressure Vessel (RPV), Revision 2, 113 pages, Electronically Approved

APP-MV01-Z0C-040, Detailed and Transient Analysis of the Direct Vessel Injection (DVI) Nozzle for the AP1000 Reactor Vessel, Revision 1, 133 pages, Electronically Approved

APP-MV01-Z0C-019, Detailed Analysis of Closure Head Penetrations (CRDM, UMI, and Vent Pipe) for AP1000 Reactor Vessel, Revision 2, 108 pages, Electronically Approved

APP-MI01-S3C-020, AP1000 Reactor Equipment Internals Structural System Model – RESM, Revision 0, 273 pages, Electronically Approved

APP-PH01-Z0R-001, AP1000 Reactor vessel Support Analysis Including Support Stiffness, Revision 0, 63 pages, January 29, 2008

Reactor Vessel Internals

APP-MI01-GLR-001, AP1000 Reactor Vessel Internals Summary Report

APP-MI01-Z0-101, AP1000 Reactor Vessel Internals Design Specification, Revision 2, 91 pages, September 19, 2008

APP-MI01-Z0-370, AP1000 Reactor Vessel Flow Skirt Design Specification, Revision 0, 49 pages, March 8, 2008

APP-MI01-GLR-001, AP1000 Generic Reactor Vessel Internals (RVI) Summary Design Report, Revision 1, 163 pages, October 3, 2008

APP-MI01-S3C-152, AP1000 Reactor Internals – Radial Support Key, Thermal and Structural Analysis, Revision 0, 120 pages, Electronically Approved

APP-MI01-Z0C-701, AP1000 Reactor Internals and Hold-Down Spring Stiffness/Reaction Calculations, Revision 0, 104 pages, Electronically Approved

APP-MI01-S3C-701, AP1000 Hold-Down Spring Elastic-Plastic Analysis for 120% Pump Overspeed Event, Revision A, 48 pages, Electronically Approved

APP-MI01-S3C-411, AP1000 Guide Tube Structural, Thermal, and Guide Tube – Control Rod Insertion Analyses, Revision 1, 152 pages, Electronically Approved

APP-MI01-S3C-410, AP1000 Guide Tube Functional Evaluation Requirements, Revision 1, 41 pages, Electronically Approved

APP-MI01-S3C-134, AP1000 Core Barrel and Core Barrel Flange Analysis, Revision 0, 76 pages, Electronically Approved

APP-MI01-S3C-020, AP1000 Reactor Equipment Internals Structural System Model – RESM, Revision 0, 273 pages, Electronically Approved

Letter from Advanced Reactor Internals Design and Analysis to David R. Forsyth, “Acceptable Fluid Velocities,” LTR-ARIDA-07-45, August 3, 2007

Letter from Advanced Reactor Internals Design and Analysis to AP1000 RVI Design and Analysis Team, “Transmittal of AP1000 Reactor Equipment System Model (RESM) Results for use in AP1000 Reactor Vessel Internals & Reactor Vessel Flow Skirt Design and Analysis,” LTR-ARIDA-08-29, Rev. 3, August 27, 2008

Letter from Advance Reactor Internals Design and Analysis to G.M. Imbrogno, T.A. Bissett, “Reconciliation of the new RESM Seismic and LOCA Results on the AP1000 Core Barrel Flange Analysis,” LTR-ARIDA-08-38, Rev. 1, September 17, 2008

Letter from Global Engineering Projects (GEP) to T. Johnson, D. Ekeroth, D. Wiseman, “Reactor Vessel Internals Summary Design Report Direct References Open Items List,” LTR-AP1000-08-101, September 29, 2008

<u>Control Rod Drive System</u>

APP-MV11-Z0-001, AP1000 Control Rod Drive Mechanism (CRDM) Design Specification, Revision 1, 82 pages, Electronically Approved

APP-MV11-S3R-002, AP1000 Control Rod Drive Mechanism (CRDM) Summary Stress Report, Revision 1, 172 pages, Electronically Approved

Attachment A - APP-MV11-S3C-002, AP1000 Control Rod Drive Mechanism (CRDM) Pressure Boundary Stress Analysis, Revision 1, 89 pages, Electronically Approved

Attachment B - APP-MV11-S3C-021, AP1000 CRDM Pressure Boundary Model, Revision 1, 53 pages, Electronically Approved

APP-MV11-S2C-011, AP1000 Control Rod Drive Mechanism Seismic Sleeve Stress Analysis, Revision 0, 46 pages, Electronically Approved

APP-GW-G1-003, Seismic Design Criteria, Revision 1, 42 pages, 11-16-2007

Steam Generator

APP-MB01-Z0R-100, AP1000 Steam Generator Summary Design Report, Rev. 1

APP-PH01-Z0R-003, AP1000 Steam Generator Supports Design, Rev. 0

APP-SS30-Z0-001, RCS Primary Equipment Supports, Rev. 0

APP- SS30-Z0-002, Design and Fabrication Requirements for Hydraulic Shock Absorbers (Snubbers)

APP-MB01-Z0-101, APP1000 Design Specification, October 31, 2007, Rev. 1

CN-NCE-APPS6-9, AP1000 Steam Generator Tube Analysis, Calculation Note, Rev. 1

CN- NCE-06-38AP1000 Steam Generator Transflow Analysis Faulted Transients, Calculation Note, Rev. 1

CN-NCE- APPSG-10AP1000 Steam Generator Shell Transition Cone and Upper Shell Analysis, Rev. 0

CN-NCE-07-29, AP1000 Seismic Analysis, AP1000 Steam Generator, Calculation Note, Rev. 1

WNEP-8661, Corrosion/Erosion/Wear Allowances for Steam Generator Materials, April 1989

Pressurizer

APP-MV20-Z0-100, AP1000 Pressurizer Design Specification, Rev. 1

APP-SS30-Z0-001, AP1000 RCS Primary Equipment Supports, Rev. 0

APP-MV20R-101, AP1000 Pressurizer Design Reports, Rev. 1

APP MV20-Z0R-001, AP1000 Pressurizer Bracket Analysis, Rev. 0

APP-MV20-Z0R-016, AP1000 Pressurizer Upper Head and Shell Analysis, Rev. 0

APP-MV20-Z0R-007, AP1000 Pressurizer Lower Head and Support Pad analysis, Rev. 0

APP-PH01-Z0R-002, AP1000 Pressurizer Support Analysis, Rev. 0

Passive RHR Heat Exchanger

APP-313DS-001, Ap1000 Passive Residual Heat Removal Heat Exchanger (PRHRHX) Design Specification, Rev. 3

APP-ME02-Z0R-101, AP1000 Passive Residual Heat Removal Heat Exchanger Design Report, Rev. 1

APP-ME02-Z0C-006, Head and Extended Flange Analysis for AP1000 PRHR Heat Exchanger, Rev. 1

APP-SS30-Z0-001, AP1000 RCS Primary Equipment Supports, Rev. 0

IRWST and Containment Recirculation Screens

APP-MY03-Z0-001, AP1000 Design Specification for IRWST and Containment Recirculation Screens for Passive Core Cooling System – Safety Related, Rev 0

APP-MY03-Z0R-001, PXS Containment and IRWST Screens Data Sheet Report, Rev. 0

APP-FA01-T2R-001, Evaluation of Debris Loading Head Loss Tests for AP1000 Simulated fuel Assembly during Post-Accident Recirculation, Rev. 0

Core Makeup Tank

APP-MT01-Z0-001, AP1000 Core Makeup Tank Design Specification, Rev. 1

APP-MT01-Z0R-001, AP1000 Core Makeup Tank Design Report, Rev. 1

APP-MT01-Z0R-010, AP1000 Analysis of Core Makeup Tank Vessel Shell Calculations of Stresses and Fatigue Usage factors, Rev. 3

APP-MT01-Z0R-010, AP1000 Analysis of Core Makeup Tank Vessel Shell Calculations of Stresses and Fatigue Usage factors, Rev. 1

Accumulator

APP-MT02-Z0-101, AP1000 Accumulator Design Specification, Rev. 1

APP-MT02-Z0R-101, AP1000 Accumulator Design Report, Rev. 1

Motor Operated Valves

APP-PV01-Z0-001, AP1000 Design Specification, 3” and Larger Motor Operated Gate and Globe Valves, ASME Code Section III, Class 1, 2, and 3

APP-PV01-Z0R-001, AP1000 Data Sheets Report, 3” and Larger Motor Operated Gate and Globe Valves, ASME Code Section III, Class 1, 2, and 3

APP-GW- G1-002, AP1000 Plant Equipment Qualification Methodology, Rev. 1

Solenoid Valves

APP-PV13-Z0-001, AP1000 Design Specification, Solenoid Valves, ASME Code Section III, Class 1, 2, and 3

APP-PV13-Z0R-001, AP1000 Data Sheets Report, Solenoid valves, ASME Code Section III, Class 1, 2, and 3

APP-GW- VP-010, AP1000 Equipment Qualification methodology and Documentation Requirements for Safety-Related Valves and Valve Appurtenances

Air Operated Valves

APP-PV14-Z0-001, AP1000 Design Specification, Air Operated Globe and Stop Check Valves, ASME Code Section III, Class 1, 2, and 3

APP-PV14-Z0R-001, AP1000 Data Sheets Report, Air Operated Globe and Stop Check Valves, ASME Code Section III, Class 1, 2, and 3

Request for Additional Information (RAI)

RAI-SRP3.9.3-EMB2-03
Reactor Vessel – Similar to RVI design as stated in August 27, 2008 memo, Westinghouse also used 20 percent load increase of RESM results in the design and analysis of RV components. However, neither the design specification nor the design reports indicate such increase in the RESM results. Justify why this 20% increase in the RESM results are not stated in the RV design specification.

RAI-SRP3.9.3-EMB2-04
Reactor Vessel Head – The RV head contains numerous holes for the CRDMs, instrumentation and the vent pipe penetrations. The design report for the vessel head was analyzed separately using a single CRDM, a single instrumentation, or a single vent penetration. The effect of multiple holes was studied based on the pressure load only on the vessel head and the effects from other loads were not addressed. Provide technical justification for not accounting the effects of multiple holes for all service load conditions.

RAI-SRP3.9.3-EMB2-05
Reactor Vessel – The design reports for the RV head penetrations indicate that the primary plus bending stresses at the J-groove weld did not satisfy the Code allowables. The reports split the stress components at these locations and justified that since the vessel wall would provide constraints in the radial and circumferential directions, the axial stress component satisfied the Code. Code does not allow splitting stresses for the purpose of satisfying the Code. Provide additional information on how the Westinghouse methodology meets the Code for J-groove weld design.

RAI-SRP3.9.3-EMB2-06
Control Rod Drive Mechanism - The design and analysis of the seismic sleeve indicates one location exceeding the ASME allowable stress limit based on an assumed “conservative” load. Provide justification how the overstress condition of this one location of the seismic sleeve will be mitigated.

RAI-SRP3.9.3-EMB2-07
Steam Generator - The transient resulting from primary system depressurization leading to external pressurization of the steam generator tubes leads to a calculated stress to allowable stress ratio of 0.96, and a fatigue limit ratio of 0.99. Since these ratios are close to their limiting values, Westinghouse is requested to examine the assumptions regarding the modeling of tube wall thinning.

The calculated stress on the tube wall depends on the wall thickness which, in turn, depends on the integrated effects of erosion, corrosion, tube wear and chemical cleaning thinning. The rates of these phenomena are computed using correlations obtained from experimental simulations. Westinghouse is requested to provide confirmation that the margins to maximum stress and fatigue limits are adequate, considering the rates of erosion, corrosion, chemical cleaning and tube wear. Confirm also that the experiments used to support evaluation of the erosion rate were performed under prototypic conditions, including flow velocity, and that the erosion rate used in the wall thickness calculations is conservatively derived from the experimental data.

RAI-SRP3.9.3-EMB2-08

IRWST and Containment Recirculation Screens - Westinghouse stated that the screen structural calculations will be performed by the screen vendor, and that the analysis is not available for review at this time. The review team was provided with the design specification and supporting data sheet report for the screens. One important input to the structural calculations is the expected debris loading on the screens, which enters into the screen pressure drop model which, in turn, is used to compute the hydraulic force on the screen and supporting structure.

Westinghouse stated that the piping insulation selected for the AP1000 is the metallic reflective metal insulation (RMI), and that no fibrous or particulate insulation is used in those areas of the plant that is subject to steam blowdown loads from postulated accidents. Westinghouse also stated that the paint in those regions of containment will be appropriately qualified, so that paint is not expected to be a source of debris. Based upon these statements, the particulate loading on the sump screen is, reasonably, expected to consist of latent debris and chemical constituent debris. The documentation provides estimates representing “Best Estimate”, “Bounding” and “Sensitivity” values of the masses of these debris categories. For the latent debris, the estimates are 14.35, 59.2 and 99 lbm, respectively. The review team did not review the origins of these masses. An observation was made, however, that the latent debris estimate that is to be used as the design value for the screen is the best estimate value of approximately 14 lbm.

Estimates of latent debris mass that may accumulate in the current generation of PWRs range from approximately 20 lbm to more than 200 lbm. Compared with these estimates, the best estimate of 14 lbm that is proposed for the AP1000 is judged by the review team as non-conservatively low. While it is likely possible to design containment cleanliness programs to sustain low latent debris inventory in containment, Westinghouse should justify the latent debris mass value used for the screen pressure drop component of the structural load on the IRWST and sump screens.

RAI-SRP3.9.3-EMB2-09

Core Makeup Tank - Table 4.4-2 and Section 6.2.2 in Appendix A-4 to APP-MT01-Z0R-010, Rev. 1, provides the summary for the original primary and secondary stress intensity range and fatigue usage factor calculations for the AP1000 analysis of core makeup tank vessel shell. This document was previously reviewed in December 2006. At the time, the primary and secondary stress intensity range was shown to exceed the criteria of $3S_m$ (= 80.10 ksi) at two cuts (Cuts A and H) on the vessel shell which led to a subsequent simplified elastic-plastic analysis of ASME Code, Section III, NB 3228.5, for fatigue evaluation. APP-MT01-Z0R-010, Rev. 3, documents the re-analysis for the core makeup tank vessel shell by incorporating the updated design seismic ground motions. However, the review team noted that the revised calculation still retains the same original tabulated results of the elastic-plastic analysis and fatigue evaluation for the vessel shell. Westinghouse is requested to clarify the documentation of the analysis results.

In addition, Table 6.4 of the revised calculation provides for the adjusted partial fatigue usage factors, whereas Table 6.5 provides the adjusted cumulative fatigue usage factors. It is not clear how the results shown in Table 6.4 would eventually lead to those shown in Table 6.5, as is implied. It is also not clear why in Table 6.5, the adjusted cumulative fatigue usage factors calculated for the outside surface of the vessel shell, except at Cut A, remain very much the same as in the original fatigue evaluation. Westinghouse is requested to explain the analysis results obtained.

cc:

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