August 28, 2002

MEMORANDUM TO: Marsha K. Gamberoni, Deputy Director
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

FROM: Lawrence J. Burkhart, AP1000 Project Manager ***/RA/***
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

SUBJECT: FORTHCOMING MEETING WITH WESTINGHOUSE REGARDING AP1000 PIPING DESIGN ISSUES

DATES & TIMES: Monday, September 9, 2002, 1:00 p.m. - 4:30 p.m.
Tuesday, September 10, 2002, 9:00 a.m. - 4:30 p.m. (closed)
Wednesday, September 11, 2002, 9:00 a.m. - 12:00 Noon (closed)

LOCATION: Westinghouse Electric Company
Westinghouse Energy Center
Monroeville, PA 15146

PURPOSE: To discuss issues associated with the implementation of piping design acceptance criteria (DAC) for the AP1000 design certification. Requests for additional information (RAIs) that were sent to Westinghouse via electronic mail on August 20, 2002, will be discussed at this meeting (please see attachment). The staff and Westinghouse representatives started discussions of these issues in a meeting on July 17, 2002 (please see meeting summary dated August 9, 2002, Agency-wide Documents Access and Management System (ADAMS) Accession No. ML02214040401). The staff has scheduled the non-proprietary portion of the meeting for Monday, September 9, 2002. The proprietary portion of the meeting will be discussed on Tuesday and Wednesday, September 10 and 11, 2002.

CATEGORY 1: * This is a Category 1 meeting. The public is invited to observe this meeting and will have one or more opportunities to communicate with the NRC after the business portion, but before the meeting is adjourned.

Certain portions of this meeting will be closed to the public because information that is proprietary in nature is planned to be discussed.

PARTICIPANTS: Participants from the U.S. Nuclear Regulatory Commission (NRC) include members of the Office of Nuclear Reactor Regulation (NRR).

NRC	Westinghouse	Brookhaven National Laboratory
L. Burkhart, NRR	M. Corletti, et al	G. DeGrassi
D. Terao, NRR		
K. Chang, NRR		

Docket No. 52-006

Attachment: RAI on implementation of piping DAC

cc w/att: See next page

CONTACT: Lawrence J. Burkhart, NRR
301-415-3053 or ljb@nrc.gov

* Commission's Policy Statement on “Enhancing Public Participation in NRC Meetings,” 67 *Federal Register* 36920, May 28, 2002. This meeting and associated discussion relates to a process which is proprietary. Therefore, certain portions of the meeting may not be open to the public. A non-proprietary summary of the meeting will be prepared and will be available upon request.

NRC	Westinghouse	Brookhaven National Laboratory
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Accession No. ML022400330

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DATE	8/27/02	8/27/02

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Request for Additional Information
AP1000 Standard Plant Design
AP1000 Design Control Document (DCD)
Tier 2 Material, Sections 3.6.2, 3.7.2, 3.7.3 and 3.9
Pertaining to Piping Design Acceptance Criteria (DAC)
Series 210 - Mechanical Engineering

General

210.030

American Society of Mechanical Engineers Code (ASME Code) cases used in the AP1000 design and analysis are listed in Table 5.2-3 of the DCD. Please identify the specific Code cases that are applicable that will be used in the design and analysis of the piping systems, including piping components and associated supports.

210.031

Section 3.9.3 of the DCD states that the design specifications and design reports will be completed by the combined license (COL) applicant or his agent. It also states that design specifications for ASME Class 1, 2, and 3 components and piping are prepared utilizing procedures that meet the ASME Code. Please provide these procedures and discuss the differences between the AP600 and AP1000 design for staff review.

210.032

Section 3.9.3 does not provide any information on the completion status for the large bore piping design and analysis. The DCD does not clearly describe where DAC will be defined and used. Please identify the specific piping systems that will be designed and analyzed as part of the COL applicant's scope.

210.033

Actual piping and pipe support design/analysis have not yet been performed and may not be completed as part of the design certification. However, the staff learned in a public meeting with Westinghouse on July 17, 2002, that preliminary piping layouts were completed and drawings were available. Please provide layout drawings and address the feasibility of including these piping layouts in the DCD.

Section 3.6.2

210.034

The third paragraph of Section 3.6.2.3.3 referenced an Electric Power Research Institute (EPRI) report (Reference 8) to confirm that for piping systems without closing check valves, there is insufficient energy in the high-frequency depressurization loadings to cause a collapse of the piping system. The tests were performed to simulate seismic and system loading until piping failure occurs. It is not clear how Westinghouse could use the results of the test report to justify not considering loadings generated from the internal system depressurization in verifying piping system integrity and operability. Furthermore, Reference 8 is Volume I, "Project

Summary," of a November 1989 draft of an EPRI report. The final report was published in October 1994. The final report should be referenced. In addition, Volume 3, "System Tests," may be more applicable than Volume I for referencing. Please modify the text and the reference accordingly. The modified version should quote specific portion(s) of the report for the purpose of the AP1000 DCD since the reference contains a number of tests and evaluations that are not applicable to the case being discussed in this section.

210.035

The completion status of the pipe rupture analysis for the AP1000 needs to be clarified. Subsection 3.6.2.5, under "Verification of the Pipe Break Hazard Analysis," states that to support design certification, the pipe rupture hazard analysis is complete except for the final piping stress analysis, pipe whip restraint design, and the as-built reconciliation. However, the staff notes that: (1) pipe stress analysis is needed to identify intermediate break locations, and (2) pipe whip restraints protect essential components from unacceptable potential consequences resulting from pipe breaks.

As described in Subsection 3.6.2.5, the as-built reconciliation includes a number of activities normally associated with design including ASME Code fatigue analysis, evaluation of pipe break dynamic loads, reconciliation to the design floor response spectra, and confirmation of the reactor coolant loop (RCL) time history seismic analysis.

Table 3.6-2, "Subcompartments and Postulated Pipe Ruptures," and Table 3.6-3, "NI Rooms with Postulated High Energy Line Breaks/Essential Targets/Pipe Whip Restraints and Related Hazard Source," are essentially identical to the corresponding tables in the AP600 DCD with the exception that larger pipe sizes are listed for certain systems.

Based on the above comments: (1) the pipe rupture hazard analysis does not appear to be complete, and (2) if pipe rupture protection is based on the AP600 design, the differences between the AP1000 and the AP600 designs may not have been adequately considered. It appears that the bulk of the pipe rupture hazard analysis design effort will be the responsibility of the COL applicant. Furthermore, considering the higher power rating and the larger pipe sizes of the AP1000 as compared to the AP600, it is reasonable to expect that the higher energy pipe rupture interactions will be potentially more damaging. A design based on pipe rupture protection for the AP600 may not be adequate. Additional information describing the Westinghouse design effort in this area and addressing these concerns should be provided.

<u>Section 3.6.4.2</u>

210.036

The COL applicant needs **to confirm** that the results of the as-designed piping stress analysis fall under the bounding analysis curve for leak-before-break (LBB) as documented in Appendix 3B. The AP1000 DCD quoted "LBB criteria" and "LBB evaluation report" in Table 2.2.3-4 under "Design Commitment and Acceptance Criteria." Please define clearly the term "LBB criteria" and "LBB evaluation report" and discuss how bounding curves, as described in Appendix 3B, will be considered by piping analysts in the design stage without completing the piping analyses and the LBB demonstration evaluation to assure the compliance to LBB criteria during the final as-built reconciliation phase.

Section 3.7.2

210.037

Section 3.7.2.5: Is there any enveloping involved in generating the floor response spectra as stated? It appears that there is only one analysis performed for a hard rock site. This should be clarified or corrected, if necessary.

Section 3.7.3

210.038

Section 3.7.3.6 states that for time history analysis, “When the responses from the three components of earthquake motion are calculated simultaneously, each component is statistically independent of the other two. For this case, the components are combined by algebraic sum.” This is incorrect. The staff position in Standard Review Plan (SRP) 3.7.2 II.6 states that the responses from each of the three components of earthquake motion may be combined algebraically at each time step. When this method is used, the components of earthquake motions specified in the three different directions should be statistically independent (i.e., the input motions not response motions, must be statistically independent). This should be clarified.

210.039

Sections 3.7.3.8.2.2 and 3.9.3 indicate that the small bore piping design and analysis will be completed by the COL applicant as part of the as-built reconciliation. Please provide the small bore piping design and analysis procedures and criteria for staff review.

210.040

Section 3.7.3.15: Westinghouse should verify that all limitations specified in Regulatory Guide (RG) 1.84 for Code Case N-411 apply to the use of 5 percent damping.

210.041

Section 3.7.3.15 of the DCD provides information on damping and references Section 3.7.1.3 for additional information. The staff found the information in Section 3.7.3.15 acceptable for piping systems. However, the following two inconsistencies were noted in Section 3.7.1.3 and need to be corrected:

Section 3.7.3.15 states that for time history analysis and independent support motion analysis of piping systems, damping values of 4 percent, 3 percent, and 2 percent are used as described in Table 3.7.1-1. Section 3.7.1.3 only specifies 5 percent damping for piping and 4 percent for the primary coolant loop.

Section 3.7.3.15 states that for subsystems composed of different material types, the composite modal damping approach with the weighted stiffness method is used to determine the composite modal damping value. Section 3.7.1.3 indicates that the composite modal damping is calculated using the strain energy method.

210.042

Section 3.7.3.17 discusses time history broadening which generally involves performing three analyses to include normal, as well as contracted and expanded time scales to account for uncertainties. References to time scale variations of "+ or - 15 percent" and to stiffness variations of "+ or - 30 percent" should be corrected to indicate "+ <u>and</u> - 15 percent" and "+ <u>and</u> - 30 percent," respectively, since both variations must be analyzed. This subsection also states that when the results are shown to be acceptable based on comparison with test data, only one analysis may be performed using normal time. For what types of loadings and under what conditions would this option be used? Provide justification.

210.043

Section 3.7.3.17 states that either direct integration or modal superposition methods may be used in performing time history analysis. However, there is no description of the direct integration analysis methodology. Please provide additional information to describe the significant aspects of this analysis methodology including computer programs, criteria for selection of time steps, specification of damping parameters, treatment of high frequency modes, and consideration of uncertainties.

210.044

The first paragraph in Section 3.7.3.17 indicates that WECAN is not used for linear time history analysis or response spectra analysis of piping systems. The last paragraph in this section discusses the use of WECAN in modal time history analysis (which is generally a linear analysis). Please clarify the application of WECAN in piping analysis and correct the apparent inconsistency in this section.

<u>Section 3.9.1</u>

210.045

Computer programs used in AP1000 analysis are discussed in DCD Section 3.9.1.2 and are listed in Table 3.9-15. For piping design certification, Section 3.9.1.2 indicates that Westinghouse will use PIPESTRESS, GAPPIPE, WECAN, AND ANSYS.

a. Provide a summary listing to identify the program or programs that will be used to analyze each specific piping system as well as the type of analysis that will be performed for each system.

b. WECAN and ANSYS are general purpose finite element analysis programs that are not normally used for piping analysis and do not have the built-in capability for performing ASME Code evaluations. Provide detailed information on their specific application in AP1000 piping analysis and on their verification and validation for this type of application.

c. GAPPIPE is a special purpose computer program for the evaluation of piping systems that use gapped supports in place of snubbers. Identify the specific AP1000 piping systems that utilize these supports. Provide detailed information on the applicability and limitations of the GAPPIPE program and on its verification and validation for use in the AP1000.

d. The PIPESTRESS program is not listed in Table 3.9-15. Instead, the table lists PS+CAEPIPE and CAEPIPE as piping analysis programs. This appears to be an oversight that should be corrected.

e. It appears that PIPESTRESS will be the primary program for piping analysis and design. Provide a summary description of this program including its capabilities, limitations, verification and validation.

f. Westinghouse reported in the July 17, 2002, public meeting that the PIPESTRESS program to be used for the AP1000 piping design and analysis is the same computer program PS+CAEPIPE that is used for the AP600. Please clarify and highlight the control and any changes in the process of converting PS+CAEPIPE to PIPESTRESS.

g. Westinghouse needs to provide three sample piping analysis problems for NRC's consideration of independent benchmarking. Specific piping systems, computer programs, types of analyses, and types of loading will be identified and agreed upon at a later date.

h. The staff learned that the three (3) piping benchmarking problems used in the AP600 were selected as verification problems for the PIPESTRESS computer code. The sample problems were re-analyzed and re-verified for every new revision of the PIPESTRESS code and, therefore, re-run of the sample problems by NRC is not required. While this is an acceptable and more effective alternative to g. above, it needs to be reflected in the AP1000 DCD for formal documentation.

210.046

Thermal hydraulic loads are applicable to several piping systems experiencing valve opening and discharge loads. Please provide the name and the description of the computer programs, along with the verification and validation, to be used for the thermal hydraulic analyses of AP1000 design. The program used to derive the forcing functions shall also be described.

Section 3.9.3

210.047

In defining the seismic events, cycles and magnitudes, Section 3.7.3.2 states as follows: ".......two safe shutdown earthquake events with 10 high-stress cycles per event. .... For ASME Class 1 piping, the **fatigue evaluation is performed based on five seismic events** with an amplitude equal to one-third of the safe shutdown earthquake response. Each event has 63 high-stress cycles."

Section 3.9.3.1.1 states "In addition, systems and components sensitive to fatigue are evaluated............by including 20 full cycles of the maximum safe shutdown earthquake stress range **or five seismic events** each resulting in 63 full stress cycles with a magnitude equal to one-third of the calculated safe shutdown earthquake response......".

Please correct the apparent inconsistency between the two sections and if Section 3.9.3.1.1 is correct, Westinghouse needs to say "whichever results in higher (or lower) cumulative usage factor."

210.048

As indicated in Section 3.9.3.1.2 under required actions in response to NRC Bulletin 88-11 request 2(c), Westinghouse states that monitoring of the AP1000 surge line is not required. However, the last paragraph in this section states that a monitoring program will be implemented by the COL holder at the first AP1000. This inconsistency should be clarified.

210.049

Section 3.9.3.1.2: The discussion on the identification and evaluation of unisolable lines susceptible to thermal cycling (Bulletin 88-08) is identical to AP600. Did Westinghouse consider the differences between the AP1000 and the AP600 with regard to parameters that may affect the thermal cycling and stratification loadings (fluid temperatures, pressures, flow rates)? Detailed calculations should be provided for staff review.

210.050

Section 3.9.3.1.2: The discussion on the identification and evaluation of the pressurizer surge line susceptible to thermal stratification (Bulletin 88-11) is identical to the AP600. Did Westinghouse consider the differences between the AP1000 and the AP600 with regard to the potential for stratification between the pressurizer and the hot leg? Specifically, it is not well known that the pressurizer could be stratified and **the heat-up and cool-down rate** could exceed the defined limit with large surge flow rate. Please describe in the DCD the control of the heat-up and cool-down procedure such that the ΔT between the pressurizer and the reactor coolant system (RCS) hot leg will be less than acceptable value(s) and pressurizer stratification will not be a concern from the stress and fatigue points of view.

210.051

Section 3.9.3.1.5, Section 3.9.3.1.3, Section 3.9.3.1.7: Westinghouse needs to clarify whether Sections 3.9.3.1.3 and 3.9.3.1.7 and the tables that they reference apply to piping or only to other ASME Class 1, 2 and 3 components. They also need to clarify that Tables 3.9-5, 3.9-9, and 3.9-10 apply to piping (these tables are not referenced in Section 3.9.3.1.5 which discusses piping).

210.052

The last paragraph in Section 3.9.3.1.5 indicates that a monitoring program for the feedwater line at the first AP1000 is identified in Subsection 3.9.3.1.2. The staff did not find any information on a feedwater line monitoring program within this subsection. Please explain and make the necessary correction.

210.053

Section 3.9.3.1.7 indicates that there are no special stress limits required to provide functional capability. This is inconsistent with Section 3.9.3.1.5 and Table 3.9-11 which discuss and provide functional capability requirements. Please clarify and make the necessary correction.

210.054

It was discussed in the public meeting on July 17, 2002, that the AP1000 is designed for 60-year life. However, when licensed, it will only be for 40-year life. Please clarify in the DCD the fatigue life considered in the design and how the environmental effects on fatigue will be addressed.

210.055

Current test data indicates that the ASME Code, Section III design fatigue curves may not be conservative for nuclear power plant primary system environments. The Section III Subgroup on Design (SGD) has formed a task group to provide recommendations to the SGD regarding the effect of the environment on Section III design fatigue curves. The NRC staff has been addressing the environmental fatigue issue in its review of license renewal applications. The NRC staff-referenced evaluations of the current test data are provided in NUREG/CR-6583, “Effects of LWR Coolant Environments on Fatigue Design Curves of Carbon and Low-Alloy Steels,” and NUREG/CR-5704, “Effects of LWR Coolant Environments on Fatigue Design Curves of Austenitic Stainless Steels,” in its license renewal reviews. Describe the method that will be used to account for the effect of the environment on the fatigue design of reactor coolant pressure boundary components in the AP-1000 plant.

210.056

Section 3.9.3.3.1: The discussion on the design of the pressurizer safety and relief valve (PSARV) module is identical to AP600. The differences, based on the staff’s understanding, between the AP600 and the AP1000 design are focused on whether the analysis of the piping system and supports has been completed at the design certification stage. Please justify in the

DCD that the AP1000 plant specific PSARV piping configuration can be designed to withstand the combined action of transient thrust forces and the thermal gradients caused by the valve opening without performing the structural dynamic and thermal fatigue analysis.

Appendix 3E

210.057

This appendix contains a discussion on the hot water heating system (VYS), which includes a limited amount of high-energy piping in the auxiliary building. No breaks are postulated in these 3-inch lines in the nuclear island because there are no anchors or fittings on these lines in the nuclear island. "No anchor or fittings" is not an adequate basis for not postulating breaks on a high energy line. Please provide more specific justification, following the criteria contained in the SRP, for the conclusion that no breaks need to be postulated.

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