September 19, 2002

Mr. Michael M. Corletti
Passive Plant Projects & Development
AP600 & AP1000 Projects
Westinghouse Electric Company
Post Office Box 355
Pittsburgh, Pennsylvania 15230-0355

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 8 - AP1000 DESIGN CERTIFICATION REVIEW (TAC NO. MB4683)

Dear Mr. Corletti:

By letter dated March 28, 2002, Westinghouse Electric Company (Westinghouse) submitted its application for final design approval and standard design certification for the AP1000.

The Nuclear Regulatory Commission (NRC) staff is performing a detailed review of your design certification application to ensure that the information is sufficiently complete to enable the NRC staff to reach a final conclusion on all safety questions associated with the design before the certification is granted.

The NRC staff has determined that additional information is necessary to continue the review. The topics covered in these requests for additional information (RAIs) include the areas of structural engineering, seismology and seismic design, hydrology and meteorology, and geotechnical engineering. These RAIs were sent to you via electronic mail on September 5, 2002. You agreed that Westinghouse would submit a response to these RAIs by December 2, 2002. Receipt of the information by December 2, 2002, will support the schedule documented in our letter dated July 12, 2002.

Enclosure 2 contains a history of previously-issued RAI correspondence.

Enclosure 3 contains three figures which are referenced in RAI 230.005. This enclosure can be accessed through the Agencywide Documents Access and Management System (ADAMS). This system provides text and image files of NRC's public documents. The enclosure mentioned above may be accessed through the ADAMS system under Accession No. ML022600628. If you do not have access to ADAMS or if there are problems in accessing Enclosure 3, contact the NRC Public Document Room (PDR) reference staff at 1-800-397-4209, 301-415-4737 or by e-mail to pdr@nrc.gov.

If you have any questions or comments concerning this matter, you may contact me at (301) 415-3053 or ljb@nrc.gov.

Sincerely,

/RA/

Lawrence J. Burkhart, AP1000 Project Manager
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

Docket No. 52-006

Enclosures: As stated

cc: See next page

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<u>Request for Additional Information (RAI)</u>
<u>AP1000 Standard Design Certification</u>
<u>Series 220 - Structural Engineering</u>
<u>Series 230 - Seismology and Seismic Design</u>
<u>Series 240 - Hydrology and Meteorology</u>
<u>Series 241 - Geotechnical Engineering</u>

<u>Design Control Document (DCD) Tier 2, Section 2</u>

240.001

The discussion in Section 2.4 (and Section 3.4.1) of the Tier 2 information on the effect of probable maximum precipitation is not clear. Without adequate site drainage, AP1000 design flood level, which is set at the finished grade level, will be exceeded. Clarify whether adequate site drainage is specified in the DCD.

240.002

Section 2.5.4 states that seismic analysis and foundation design for rock sites is described in Sections 3.7 and 3.8 and that the AP1000 certified design is based on the nuclear island being founded on rock. In Table 2.1 (Sheet 1 of 2), the foundation is characterized by a low strain shear wave velocity equal to 3,500 feet-per-second (ft/sec). Section 3.7.2 states that fixed base seismic analyses are performed for the nuclear island at a rock site, and Subsection 3.7.2.4 states that soil-structure interaction effect is not significant for the nuclear island founded on rock with a shear wave velocity greater than 3,500 ft/sec.

For the AP600 nuclear island, a shear wave velocity of 3,500 ft/sec is associated with soft rock sites and the effect of soil-structure interaction (SSI) was found to be not negligible. The SSI effect is negligible only for hard rock sites that are characterized by a shear wave velocity of 8,000 ft/sec. The AP1000 nuclear island is taller and more massive than the AP600 nuclear island. Therefore, the validity for performing a fixed-base analysis that neglects the effect of the SSI for the AP1000 nuclear island founded on a rock site with a shear wave velocity of 3,500 ft/sec needs be substantiated. Please provide clarifying information.

240.003

Subsection 2.5.4.3, “Settlement,” does not address the hard rock site conditions. Please provide a discussion addressing the hard rock site conditions or your basis for this omission.

241.001

The staff’s review of Table 2-1 identified the following issues:

A. Shear wave velocity of 3,500 ft/sec is defined for soil. All other references to shear wave velocity refer to rock or hard rock. The DCD does not specifically clarify the definition of assumed foundation properties for the design. Please clarify your position regarding the shear wave velocity versus restriction of the AP1000 design to rock or hard rock site.

B. The “average allowable static soil bearing capacity” of 8,400 pounds-per-square foot (psf) was specified in this table. If the DCD is applicable to hard rock sites only, Westinghouse needs to demonstrate the appropriateness of this definition. In addition, it is not clear if the definition is based on an assessment of the average strength of the hard rock or if it refers to the load associated with a given relative displacement of the foundation. Please clarify.

241.002

Subsection 2.5.4.6.5 indicates that dynamic characteristics for rock, namely low strain shear velocity and material damping, need to be compared to the assumptions included in the analysis. It is not clear where either parameter has been used in the analysis and design. Please provide clarifying information. Please provide additional discussion on this issue.

241.003

Subsection 2.5.4.6.7 refers to static soil bearing capacity and that the Combined License (COL) applicant will evaluate the site-specific dynamic bearing capacity. It is not clear where either parameter will be used in the design. Please clarify.

<u>DCD Tier 2, Section 3.3</u>

240.004

Section 3.3.3 requires the COL applicant to address the site interface criteria for wind and tornado. However, no description was provided. Westinghouse is requested to describe these interface criteria in the DCD.

<u>DCD Tier 2, Section 3.7</u>

230.001

In the first paragraph of Subsection 3.7.1.2 (Page 3.7-1), Westinghouse states that site-specific time histories may be used as defined in Subsection 2.5.4.5.5. However, Subsection 2.5.4.5.5 does not exist. Please clarify this definition in the DCD.

230.002

For the case of the AP1000 nuclear island founded on a hard rock site with a 40-foot embedment, described in Subsection 3.7.1.1, “Design Response Spectra,” and in the last sentence in Page 3.7-2, you stated that the design ground response spectra are applied at the foundation level in the free field. However, in Subsection 3.7.1.2, “Design Time History,” you stated that the design time histories are applied at the finished grade in the free field. Also, as stated in Subsection 3.7.1.2, the three components of the ground motion time history were derived from the design response spectra. Please address the following issues:

A. The location where the ground motion (design response spectra and design time histories) is applied should be consistent throughout the entire AP1000 DCD.

B. Subsection 3.7.2.1 indicates that SSI effects are negligible for the AP1000 nuclear island founded on hard rock and that the effect of embedment below grade is not considered in the equivalent static and time history analyses of the structure. The staff's concern is that if the plant is founded on a hard rock surface and is surrounded by soil, the application of the design ground motion at the ground surface may result in an underestimation of the seismic responses of the plant without considering the SSI effects. Please elaborate regarding the staff's concern.

C. Please provide a description in the DCD that explains: (1) how lateral soil pressures (dynamic, active and/or passive) due to the embedment (plant embedded in the rock and plant founded on rock and surrounded by soil) are to be calculated, (2) how the out-of-phase motion between the soil burden and the side walls of the nuclear island structures will be accounted for in the assessment of the lateral soil pressure, and (3) how the soil lateral pressure will be incorporated into the design of the nuclear island side walls, basemat and below grade interior members.

230.003

In DCD Subsection 3.7.2.1, “Seismic Analysis Methods,” Westinghouse stated that the computer program ANSYS is to be used to perform equivalent static analyses and mode superposition time history analyses. The following items were identified by the staff for clarification:

A. Subsection 3.7.1.3 provides a description of how the composite modal damping is calculated for the seismic analysis. Please demonstrate, in the AP1000 DCD, that the method for calculating the modal damping adopted in the ANSYS computer code is consistent with the method described in Subsection 3.7.1.3.

B. In Table 3.7.2-16, Westinghouse stated that the 100%, 40%, 40% combination technique is applied to combine the three components of the seismic responses when the ANSYS computer program is used. Please clarify whether the ANSYS computer program has the option of using the 100%, 40%, 40% combination technique.

230.004

For the damping values shown in Table 3.7.1-1, identify (a) those damping values that are based on American Society for Civil Engineers (ASCE) Standard 4-98, and (b) bases or source references for the damping values for fuel assembly, control rod drive mechanisms, cabinets and panels for electrical equipment, and equipment such as welded instrument racks and tanks. Since the AP1000 nuclear island structures are to be analyzed for the safe shutdown earthquake (SSE), the damping values, recommended in Regulatory Guide (RG) 1.61, “Damping Values for Seismic Design of Nuclear Power Plants,” for an SSE, are acceptable to the staff. Westinghouse should clarify when, where, and how the ASCE Standard 4-98 damping values are to be used.

230.005

The horizontal design ground motion response spectrum (and associated enveloping time histories) is indicated to be appropriate for application to the Eastern United States (EUS) sites at a mean annual probability of exceedance of 10^{-4} per year. Recent developments in ground motion assessment show that spectral shapes applicable to the EUS rock sites are rich in the high frequency range. These shapes of ground response spectra indicate that the peaks at high frequencies of 10 hertz (hz) and above are higher than those used for the AP1000 design. Please demonstrate that the design of the AP1000 structures, systems and components, based on its proposed design ground response spectra shown in Figure 3.7.1.1, will be an adequate design. The figures in Enclosure 3 (Figures 1 through 3) show the result of recent development on the ground motions.

230.006

In Subsection 3.7.2.1, “Seismic Analysis Methods,” Westinghouse replaced the description of the response spectrum analysis method (Subsection 3.7.2.1.1) with the equivalent static acceleration analysis method when converting the AP600 DCD to the AP1000 DCD. Also, the application of the response spectrum analysis method was eliminated from Table 3.7.2-14, “Summary of Models and Analysis Methods.” The following areas were identified by the staff for clarification:

A. If the response spectrum analysis method will not be used for the AP1000 design, Westinghouse should clearly state that this method will be excluded from the AP1000 DCD. Otherwise, a new subsection should be developed specifically to address the use of the response analysis method.

B. If the response spectrum analysis method will not be used for the AP1000 design, any description related to this method should be deleted from Section 3.7.2. Examples are found in: (1) the third paragraph of Subsection 3.7.2.6 (Page 3.7-13), (2) Subsection 3.7.2.7 (Page 3.7-14), (3) Table 3.7.2-16 (Page 3.7-74), and Figures 3.7.2-17 through 3.7.2-19.

230.007

A discussion of seismic analyses using equivalent static acceleration analysis and time history analysis methods is provided in Section 3.7.2. Describe how the results (member forces and floor response spectra) from either method will be used in the AP1000 plant design. Also, when using the equivalent static acceleration analysis method in conjunction with a three-dimensional (3D) finite element model, describe how the seismic effects (member forces or accelerations) obtained based on the nuclear island stick model will be used to calculate the seismic design forces in all elements, and how you account for the out-of-plane effects due to seismic excitation in the design of walls, floors and attached safety-related subsystems.

230.008

During the AP1000 pre-application review, Westinghouse indicated that only the hard rock site will be considered in the design certification application of the AP1000 (see Westinghouse letter dated February 13, 2002, ADAMS Accession No. ML020640065). Westinghouse also stated in

DCD Subsection 3.7.2.1.2, that for the hard rock site, the SSI effect is negligible. Therefore, for the hard rock site, the nuclear island is analyzed as a fixed-base structure, using "...foundation media." Based on the definition provided in the AP600 DCD, Appendix 2B (Table 2B-1), the shear wave velocity for hard rock sites should be 8,000 ft/sec or higher. However, Westinghouse defined, in DCD Tier I material, Table 5.0-1, the rock site as a site with the shear wave velocity equal to or higher than 3,500 ft/sec and stated in DCD Section 3.7.2 that fixed-base seismic analyses are performed for the nuclear island at a rock site. In the DCD, Westinghouse should address the following:

A. State whether the site condition used in the design certification application for the AP1000 is a hard rock site or a rock site.

B. If the hard rock site condition is to be used, specify the shear wave velocity for a hard rock site (i.e., 8,000 ft/sec or higher based on the AP600 definition) which can reasonably simulate the fixed base condition for the AP1000 design. In this scenario, you are also requested to delete any design information not related to the hard rock site.

C. If the rock site with a shear wave velocity equal to 3,500 ft/sec or higher is to be used, provide your basis to justify that the use of a fixed-base structural model can lead to adequate calculation of the seismic responses (member forces and floor response spectra) of the nuclear island structures founded on a rock site.

230.009

The fifth paragraph of Section 3.7.2 (page 3.7-6) states that Table 3.7.2-14 summarizes the types of model and analysis methods that are used in the seismic analyses of the nuclear island. It also summarizes the type of results that are obtained and where they are used in the design. With regard to the modeling of the nuclear island, the staff identified the following items for clarification:

A. The location (elevation) of "fixed base" should be clearly specified in the DCD.

B. Westinghouse should provide information regarding the model, analysis methods, and computer codes to be used for calculating the overturning moment, sliding force, floating force, etc. Also, describe how the calculated overturning moment, sliding force, and floating force are to be used for evaluating the dynamic stability of the nuclear island and the foundation mat design.

230.010

Figure 3.7.2-18 shows the combined fixed-base stick model for the time history analyses. In this figure, three lateral supports are provided to represent the support for hard rock to grade. The staff's review identified the following items for clarification:

A. The last sentence of the third paragraph of Subsection 3.7.2.1.1 states that the support provided by the embedment below grade is not considered in the seismic analyses. This statement is not consistent with the lateral support provided for the coupled shield and auxiliary building stick model. This inconsistency should be clarified.

B. Since there is no contact between the containment internal structures and the hard rock foundation, Westinghouse should explain why these two lateral supports were included in the containment internal structure lumped mass stick model to consider the effects of the hard rock support.

230.011

In the last paragraph of Subsection 3.7.2.1 (Page 3.7-8) and Table 3.7.2-4 (Page 3.7-61), Westinghouse states that the combined lumped-mass stick model of the nuclear island structures is fixed at the top of the basemat at Elevation 66'-6" to simulate the hard rock foundation media. The staff's review identified the following items for clarification:

A. Regarding the appropriateness of using a fixed-base model to simulate the nuclear island structures founded on a hard rock foundation media, Westinghouse should provide a detailed description of construction technique and construction sequence (either in Section 2.5 or in Section 3.8.5) to demonstrate that the nuclear island structures founded on hard rock foundation media can be reasonably represented by a fixed-base structural model.

B. In order to include the mass effects of the foundation mat, the fixed base should be located at the bottom of the foundation mat (Elevation 60'-0") instead of the top of the mat (Elevation 66'-6"). The staff is unclear about your rationale for excluding the mass effects from the foundation mat in the seismic analyses that are based on the current fixed base model (at Elevation 66'-6"). The staff suspects that the calculated seismic responses (member forces, nodal accelerations, overturning moments, base shear, etc.) will be underestimated. Westinghouse should provide a justification to show that the seismic responses calculated based on the seismic model fixed at the top of the foundation mat (Elevation 66'-6") will result in a more conservative design than that in which the model is fixed at the bottom of the basemat (Elevation 60'-0").

230.012

Subsection 3.7.2.2 states that the time history seismic analyses of the nuclear island consider vibration modes having a frequency up to 114 hz. Subsection 3.7.1.2 states that in the fixed-base modal superposition time history analyses of the nuclear island, the time step of the ground motion time histories is 0.005 second. Given the time step of 0.005 second, a time history analysis is typically accurate only for modes having a frequency up to about 50 hz. Therefore, Westinghouse should provide verification of the accuracy of the time history analysis results for modes having a frequency between 50 hz and 114 hz.

230.013

Both Subsection 3.7.2.1 and Table 3.7.2-14 specify only two methods for the seismic analyses of the nuclear island. These two methods are the equivalent static acceleration analysis method and the modal superposition time history analysis method. Table 3.7.2-16, however, states that both the modal superposition time history analysis method and the response spectrum analysis method are used in the dynamic seismic analysis of the 3D stick model of the nuclear island. Westinghouse is requested to:

A. reconcile the contradiction between Subsection 3.7.2.1/Table 3.7.2-14 and Table 3.7.2-16,

B. clarify the purpose of applying both the time history method and the response spectrum method of analysis to the 3D stick model of the nuclear island, and

C. clarify the purpose of the comparison of responses between the time history method and response spectrum method of analysis as stated in Subsection 3.7.2.12.

230.014

Subsection 3.7.2.1.2 states that in the time history analysis of the 3D stick model of the nuclear island, the base of the stick model is fixed at the top of the basemat at Elevation 66'-6" and lateral supports due to soil or rock below grade is omitted; thus, resulting in higher responses than analyses considering full lateral support below grade. This may be true for floor response spectra provided that the issue associated with location of the point of application of the design ground motion is clarified. However, considering full lateral support due to structural embedment may result in a shift of the floor spectrum peaks toward higher frequencies. Please verify that the 15% peak broadening of the floor response spectra resulting from the fixed-base stick model neglecting the lateral support below grade would account for the spectrum peak shifting due to the lateral support below grade. In addition, please verify the accuracy of Figure 3.7.2-18 that shows lateral supports below grade and hence appears to contradict Subsection 3.7.2.1.2.

230.015

For the development of seismic model of the containment vessel, Westinghouse stated in Subsection 3.7.2.3.2 (the last paragraph of Page 3.7-11) that the polar crane is parked in the plant north-south direction with the trolley located at one end near the containment shell. This requirement should be specified as an interface item for the COL applicant.

230.016

The second paragraph of Subsection 3.7.2.5 (Page 3.7-12) states that the floor response spectra for the design of subsystems and components are generated by enveloping the nodal response spectra determined for the hard rock site. Please explain how and where the enveloping technique is applied.

230.017

When the design of the AP600 coupled shield and auxiliary building complex (the building complex) was converted to the AP1000 building complex, Westinghouse increased the height of the shield building cylindrical wall and the volume of the passive containment cooling tank (i.e., the mass of water contained in the tank and the tank structural mass) by a significant percentage. The other portions of the AP1000 building complex remain the same as those of the AP600. With these design changes, the staff expects that the fundamental frequency of the AP1000 building complex should be lower than that of the AP600 building complex. However, when Table 3.7.2-1 of these two designs was compared, the staff finds that the fundamental frequency of AP1000 is 13% higher than that of the AP600. Please provide additional information addressing the staff's observation.

230.018

It is the staff's understanding that the layouts of the coupled shield and auxiliary buildings for the AP1000 and the AP600 are the same and only the height of the shield building and the size of the passive containment cooling water storage tank were increased. As a result of these design changes, the dominating frequency (6.065 hz) of the AP1000 in the vertical direction is lower than that of the AP600 (6.77 hz). From Figure 3.7.1-2, "Vertical Design Response Spectra - Safe Shutdown Earthquake," one can find that the vertical responses (accelerations) of the coupled shield and auxiliary buildings for the AP1000 should be higher than those for the AP600. However, the comparison of the two designs summarized in Table 3.7.2-5 and Figure 3.7.2-4 shows an opposite conclusion. The staff's review identified the following areas for clarification:

A. Westinghouse used a detailed model between Elevation 306'-3" (the top of the tank roof) and Elevation 241'-0" (the bottom of the air vent columns) for the AP600, while it used a less detailed model for the AP1000. Please provide an explanation for the change in models and reasons for using the less detailed model for the AP1000.

B. As summarized in Table 3.7.2-5 of DCD, Revision 0, the comparison of the vertical seismic responses (maximum absolute nodal accelerations) of the two designs indicates that the dynamic amplification in the vertical direction is higher for the AP600 than for the AP1000. Based on our engineering judgement, it is the staff's expectation that the results should be reversed because there is no change to the building wall thickness for both designs and the shield building complex of the AP1000 is more massive than that of the AP600. Westinghouse is requested to provide an explanation to address the staff's observation.

The staff's observation regarding the dynamic amplification discussed in (a) and (b) above are also applicable for the steel containment vessel.

230.019

As shown in Table 3.7.2-1, "Modal Properties for the Coupled Shield and Auxiliary Buildings Lumped-Mass Stick Model," the dominating frequency in the vertical direction is 6.055 hz for the AP1000. This frequency is lower than that of the AP600 (6.77 hz). From Figure 3.7.1-2, "Vertical Design Response Spectra - Safe Shutdown Earthquake," one can find that the vertical response (acceleration) of the coupled shield and auxiliary buildings for the AP1000 should be higher than that of the AP600. However, as indicated in AP1000 Table 3.7.2-5 and AP600 Table 3.7.2-5 (Sheet 1 of 4), the vertical responses of the AP600 coupled shield and auxiliary buildings are consistently higher than those of the AP1000 coupled shield and auxiliary buildings. Please provide a discussion addressing these expectations.

DCD Tier 2, Section 3.8.2

220.001

In order to verify the design adequacy of the AP600, Westinghouse conducted various performance tests for unique AP600 systems. The outcome of these tests was used to define the resulting loads for the design of seismic Category I structures (containment vessel, containment internal structures, and coupled shield building and auxiliary building). In AP1000 DCD Section 1.5, “Requirements for Further Technical Information,” Westinghouse states that the AP600 test results are also applicable to the AP1000, and cites Reference 25 [WCAP-15613, “AP1000 PIRT and Scaling Assessment,” (Proprietary), WCAP-15706 (Nonproprietary), dated March 2001] for documentation of its evaluation to support this conclusion. DCD Table 1.5-1 provides a list of AP600 tests and AP1000 evaluations with references to test and evaluation documentation. However, the details of how design loads were determined for the structural evaluation are not evident from these reports. The design of the AP1000 containment structure, the containment internal structures and other Category I structures (i.e., shield building, auxiliary building, containment air baffle, cable tray supports, and heating, ventilation, and air conditioning [HVAC] supports) needs to consider the effects of loads from thermal striping of the exterior surfaces of the taller AP1000 containment, the loads from the higher mass and energy release for AP1000 containment internal structures, and the loads that are applicable to the other Category I structures for the AP1000. Therefore, please provide a detailed technical basis for the loads for the three types of structures discussed below.

A. loadings on the AP1000 containment, due to thermal striping.

B. loadings on the AP1000 containment internal structures.

C. loadings on other AP1000 Category I structures (i.e., shield building, auxiliary building, containment air baffle, cable tray supports, and HVAC supports).

220.002

For the AP600 containment cylindrical shell, the nominal design thickness is 1.625". However, for the bottom cylindrical section, Westinghouse increased the shell thickness to 1.75" in order to “provide margin in the event of corrosion in the embedment transition region” (quote from AP600 DCD). For the AP1000 containment cylindrical shell, the nominal design thickness is a uniform 1.75" for the entire length. The 1.75" thickness just meets the minimum thickness requirements (1.7455") of the 1998 American Society of Mechanical Engineers (ASME) Code Section III, Subsection NE, Paragraph NE-3324.3(a), based on 59 pounds-per-square inch (psi) design pressure, 300°F design temperature, S = 26.4 ksi (thousand pounds-per-square inch), and R = 780". There is no margin in the nominal design thickness for corrosion allowance. Therefore, Westinghouse is requested to provide a technical justification for:

A. eliminating the corrosion allowance for the embedment transition region (deviation from AP600 design philosophy), and

B. making no provision for general corrosion of the containment shell over its 60-year design life in defining the nominal design thickness. Paragraph NE-3121 specifically addresses corrosion allowance for Class MC components.

220.003

In DCD Section 3.8.2, Westinghouse stated that the containment shell material is SA-738, Grade B. Westinghouse further stated, in the same DCD subsection, that this material is included in the ASME Code but it is not applicable for containment vessel in the 2000 Addenda. This material has been approved for containment vessels by Code Case N655. The code case was approved by the ASME Code committee on February 25, 2002, but is not yet published.

The code case approves the use of SA-738, Grade B for Class MC components. Based on paragraph (b) of the reply to the inquiry, the allowable stress intensity (S_{mc} or S) for SA-738, Grade B used in Class MC components is 1.1 x 24.0 = 26.4 ksi at 300°F. This is based on the 1998 ASME Code, Section II, Part D, Table 1A value for S at 300°F, which is 24.0 ksi. This stress intensity limit is applied to the general primary membrane stress intensity at the design pressure and temperature. The hoop stress in the cylinder is +26,297 pounds-per-square inch (psi), based on 59 psi design pressure, t = 1.75", and r = 65' x 12 = 780". The radial stress is -59 psi at the inside shell surface and zero at the outside shell surface, resulting in an average radial stress of -59/2 = -29.5 psi. Therefore, the general primary membrane stress intensity is 26,297 + 29.5 = 26,326.5 psi, which is just below S_{mc} = 26,400 psi, at the design temperature.

Please provide justification for adopting allowable stress values for SA-738 Grade B material, which are not of yet included in the current version of the ASME Code, for Class MC components.

220.004

Code Case N-284-1 (Revision 1 to N-284) on metal containment buckling is currently unacceptable to the staff because of errors contained in the initial version. Before formal staff acceptance, the staff must confirm that the previously identified errors in N-284-1 have been corrected in the latest version. The existing staff qualification relating to the application of axi-symmetric-based design criteria to non-symmetric details such as hatches will be retained. In the AP1000 DCD, Westinghouse has referenced Code Case N-284-1, as documented in the 2001 Edition of the Nuclear Code Case volume, as one technical basis for demonstrating the buckling resistance of the AP1000 containment shell. In the AP600 DCD, Westinghouse referenced Code Case N-284, Revision 0, with supplemental requirements as documented in Appendix 3G of the AP600 DCD. The staff found this acceptable for the AP600. Therefore, Westinghouse is requested to provide its technical justification for the acceptability of the latest version of Code Case N-284-1 by identifying the differences and demonstrating an equivalent level of safety when compared to Code Case N-284, Revision 0, plus the supplemental requirements of AP600 DCD Appendix 3G.

220.005

In the AP1000 DCD Section 3.8.2 “Steel Containment,” Subsection 3.8.2.6, “Materials, Quality Control, and Special Construction Techniques” (Page 3.8-15), Westinghouse states that “The basic material is SA738, Grade B, plate. This material has been selected to satisfy the lowest service metal temperature requirement of -15°F. This temperature is established by analysis for the portion of the vessel exposed to the environment when the minimum ambient air temperature is -40°F. Impact requirements are as specified in NE-2000.” The staff notes that for the AP600 the lowest service metal temperature requirement is -40°F. Westinghouse is requested to provide the details of the analysis conducted for the AP1000 that justifies the change in the minimum service temperature, from -40°F for AP600 to -15°F for the AP1000, and also to indicate whether SA-738, Grade B meets the impact requirements of NE-2000 if the minimum service temperature requirement is -40°F.

<u>DCD Tier 2, Section 3.8.3</u>

220.006

AP1000 DCD Subsection 3.8.3.1, “Description of the Containment Internal Structures,” states that “The steel surface plates of the structural modules provide reinforcement in the concrete and anchor the structural modules to the base concrete.” According to Figure 3.8.3-8 and the AP600 design, the structural modules also require anchoring to the concrete with mechanical connectors/rebars. Westinghouse is requested to clarify the statement in Subsection 3.8.3.1, specifically explaining whether the steel surface plates are sufficient to provide anchorage to the concrete or if additional mechanical connectors/rebars are also required. If additional mechanical connectors/rebars are required, identify where the details are described in the AP1000 DCD or provide the details as part of the response.

220.007

AP1000 DCD Subsection 3.8.3.3.1, “Passive Core Cooling System [PCCS] Loads,” describes the pressure and thermal transients associated with operation of the PCCS which are used to evaluate structures inside containment. Some of the water temperature transients have changed from the AP600 design and it is not clear how these have affected the analysis and design of the structural modules. Therefore, please address the following issues:

A. The transient temperature was revised from 240°F reached in 5.5 hours (AP600) to 250°F reached in 3.5 hours (AP1000). Provide a discussion to explain the change and how this change was considered in the analysis and design of the AP1000 modules.

B. The extreme transient starting temperature used for the structural design was revised from 50°F (AP600) to 70°F (AP1000). This would seem to be less extreme than the 50°F case in the AP600 design. Provide the basis for this change and explain how this change was considered in the analysis and design of the AP1000 modules.

220.008

AP1000 DCD Subsection 3.8.3.4.1.2, “Stiffness Assumptions for Global Seismic Analyses,” indicates that the in-plane concrete shear stresses calculated for the AP600 containment internal structural modules would increase slightly for the AP1000 due to the increased height of the modular walls and increased mass and size of the steam generators and pressurizer. In addition, this subsection states that the stresses will still be well below the magnitude causing significant cracking of the concrete, so the monolithic assumption is still appropriate. Please provide the technical basis to demonstrate the above statements and conclusions.

220.009

Hydrodynamic analyses performed for the AP600 are described in AP1000 DCD Subsection 3.8.3.4.2. This subsection indicates that due to the “minor” differences between the AP600 design and the AP1000 design, the 5 psi pressure design basis for the tank boundary is also applicable to the AP1000. From the information provided, it is not evident that the changes in the structural elements and masses can be considered to be “minor.” Therefore, Westinghouse is requested to provide the following information:

A. The technical basis for concluding that the increase in wall heights and mass of the steam generator and pressurizer will have a minor effect on the structural frequencies.

B. Explain how the range of frequencies considered in the AP600 time history analyses adequately cover the expected frequency shifts caused by the differences between the AP600 and the AP1000 design.

C. What was the margin between the maximum wall pressure calculated from the analyses and the 5 psi pressure used as the design basis for the AP600 tank boundary?

220.010

AP1000 DCD Subsection 3.8.3.5, “Design Procedures and Acceptance Criteria,” indicates that the SSE loads are derived from the response spectrum analysis of a 3D finite element model representing the containment internal structures and refers to Section 3.7.2 for the analysis method. Subsection 3.7.2.1.1 discusses the use of equivalent static acceleration analysis for containment internal structures and the coupled shield and auxiliary buildings. However, no details of the analysis method are provided. There is no discussion of response spectrum analysis in Section 3.7.2. Table 3.8.3-2 identifies that an equivalent static analysis of the 3D finite element model is utilized to obtain in-plane seismic forces for the design of floors and walls for the containment internal structures fixed at Elevation 82'-6". It is unclear what method is used to obtain out-of-plane seismic forces for design of floors and walls for the containment internal structures. The staff notes that this is a departure from the AP600 approach, which utilized the response spectrum analysis method.

In order to clarify the analysis method that is actually employed, please provide information regarding the following issues:

A. (1) a description of the use of response spectrum analysis and equivalent static analysis in defining the seismic design loads for the containment internal structures, specifically identifying where each of the methods was employed, either singly or in combination, and (2) an indication of how the three simultaneous components of seismic input motion are applied in the analyses and design.

B. a detailed description of how the equivalent static analysis method was implemented for the containment internal structures, the auxiliary building, and the shield building, including: (1) how possible seismic amplification due to out-of-plane flexibility of walls and floors was considered; (2) how the equivalent static acceleration was calculated; (3) numerical values for the significant modal frequencies; and (4) numerical values for the equivalent static accelerations used in the analyses.

C. the technical basis for concluding that a comparable level of safety is achieved for the AP1000, compared to the AP600.

These concerns are applicable to Section 3.8.4, “Other Category I Structures.”

220.011

AP1000 DCD Figure 3.8.3-1 (sheets 1 through 7) refers to three types of wall modules: CA Structure Wall Module, Left-in-Place Form, and CA Structure Module With Single Surface Plate. Please provide the following information:

A. A description, design approach, and analytical methods are provided for the first two types of modules; however, no descriptive information has been identified for the CA Structure Module With Single Surface Plate. A description for the CA type module similar to the information provided for the other two modules should be provided.

B. On this figure, sheets 1, 2, 4, 6, and 7, there are solid heavy lines (without tick marks) for a structural module. However, this marking is not identified on the “Key.” Please explain what is meant by the solid heavy line marking.

220.012

Some figures in AP1000 DCD Section 3.8.3 do not provide sufficient details. Therefore, please provide the following information:

A. Figure 3.8.3-4 does not provide sufficient details for the reactor vessel supports. More detailed information is needed, comparable to the level of details provided in the AP600 DCD, regarding the embedded anchor bolts, details about the embedded steel plates, provisions allowing for thermal expansion and seismic resistance, welds, and dimensions and sections of support elements.

B. Figure 3.8.3-5 does not provide sufficient details for the steam generator supports. More information needs to be provided, comparable to the level of details in the AP600 DCD.

C. The AP1000 DCD does not provide details about the steel reinforcement in the containment internal structures concrete base. Figure 3.8.3-7 in the AP600 DCD provided details about the steel reinforcement in the concrete base, but this figure was deleted in the AP1000 DCD. Please provide details that are comparable to those provided in the AP600 DCD.

DCD Tier 2, Section 3.8.4

220.013

AP1000 DCD Subsection 3.8.4.2, “Applicable Codes, Standards and Specifications,” references American Concrete Institute (ACI)-349-01, plus supplemental requirements as indicated in Subsection 3.8.4.5. Subsection 3.8.4.5.1 states “Supplement requirements for ACI-349 are given in the position on RG 1.142 [TITLE] in Appendix 1A.” The staff notes that this statement and the discussion in Appendix 1A are not designated Tier 2*, although ACI-349-01 itself is designated Tier 2*. Subsection 3.8.4.5.1 also states “[Design of fastening to concrete is in accordance with ACI-349-01, Appendix B.]*”

In Appendix 1A, Westinghouse indicates that the AP1000 position “conforms” to all applicable Regulatory Positions C.1 through C.15 of RG 1.142, Rev. 2, November 2001. A general exception is noted because the RG endorses ACI-349-97, not ACI-349-01. Westinghouse indicates that “The AP1000 uses the latest version of industry standards as of October 2001.” In reviewing Appendix 1A, pages 1A-52 and 1A-53, the staff noted two apparent typographical errors. In relation to C.6, it should be “Section 9.2.1" instead of “Section 9.3.1,” and in relation to C.15, it should be “Section 11.6” instead of “Section 1.6.”

Since the staff has not formally reviewed and endorsed ACI-349-01 at this time, Westinghouse is requested to specifically identify all deviations between ACI-349-97/RG 1.142 and ACI-349-01/Westinghouse Position that affect the AP1000 design, and to provide the technical basis for ensuring that a comparable level of safety is achieved for each such deviation. In addition, Westinghouse is requested to (1) clarify and correct the inconsistency in designation of Tier 2* material noted above, and (2) verify and correct the typographical errors noted above.

220.014

AP1000 DCD Subsection 3.8.4.2, “Applicable Codes, Standards and Specifications,” references American Institute of Steel Construction (AISC) N690-94, plus supplemental requirements as indicated in Subsection 3.8.4.5. Subsection 3.8.4.5.2 identifies the same supplemental requirements previously accepted by the staff for AISC N690-84. However, AISC N690-94 has not been formally reviewed and accepted by the staff at this time. Therefore, Westinghouse is requested to identify all deviations between AISC N690-84 (with NRC-accepted supplemental requirements) and AISC N690-94 (with identical supplemental requirements) that affect the AP1000 design, and to provide the technical basis for ensuring that a comparable level of safety is achieved for each such deviation.

220.015

AP1000 DCD Subsection 3.8.4.3.1.4, “Abnormal Loads,” discusses loads generated by a postulated high-energy line break accident, including subcompartment pressure loads and subcompartment temperatures. It is stated that “Determination of subcompartment pressure loads (temperatures) is discussed in Subsection 6.2.1.2.” The staff reviewed Subsection 6.2.1.2, but could not identify any quantitative data on subcompartment pressures and temperatures. This also applies to subcompartments inside containment (AP1000 DCD, Tier 2 Material, Section 3.8.3).

Please provide quantitative pressure and temperature results from the AP1000 subcompartment analyses for both high and medium energy line breaks, as applicable, for all subcompartments inside and outside containment in which a significant line break has been postulated. In addition, demonstrate that quantitative data supports the use of a uniform 5 psi subcompartment design pressure for the AP1000, and describe the methodology used to evaluate the effects of temperature transients resulting from the postulated line breaks. Same concerns are extended to Section 3.8.3, “Concrete and Steel Internal Structures of Steel Containment.”

DCD Tier 2, Section 3.8.5

220.016

The third paragraph of Subsection 3.8.5.1 states that resistance to sliding of the concrete basement foundation is provided by passive soil pressure and soil friction. For the case of the AP1000 nuclear island founded on a hard rock site, Westinghouse is requested to:

A. provide a description of construction techniques and sequence to ensure that the surrounding soil or rock (embedment) will provide enough passive pressure to prevent the nuclear island from sliding.

B. clarify the applicability of the words “soil friction” to the AP1000 design.

C. indicate how passive lateral pressures and base soil friction components can be properly estimated, considering consistent lateral displacements for both forces.

220.017

Section 3.8.5 contains a number of apparent inconsistencies related to the designation of Tier 2* material and the status of the AP1000 basemat design.

Subsection 3.8.5.4.3, “Design Summary of Critical Sections” references both Table 3.8.5-3 and Figure 3.8.5-3 as showing the basemat reinforcement details for the basemat critical sections. The design of the critical sections is designated Tier 2* in the text of Subsection 3.8.5.4.3, and Table 3.8.5-3 is also designated Tier 2*. However, in Figure 3.8.5-3, only sheets 1,2, and 5 are designated Tier 2*, while sheets 3 and 4 are unmarked.

Table 3.8.5-3 includes Note (5), indicating that “The results are representative for the AP1000 and may be updated when structural calculations are completed.” However, Figure 3.8.5-3 does not have a comparable note, implying that the information provided reflects the AP1000 final basemat design.

Please provide an explanation for these apparent inconsistencies by (1) identifying what is Tier 2*, what is not Tier 2*, and the technical basis for the proposed designation, and (2) describing the status of the AP1000 final basemat design and the relationship between the information in Table 3.8.5-3 and Figure 3.8.5-3 to the AP1000 final basemat design.

220.018

Table 3.8.5-2 lists factors of safety for floatation, overturning, and sliding applicable to the “hard rock condition,” calculated in accordance with Subsection 3.8.5.5, “Structural Criteria.” Since there is no indication that these factors of safety are subject to change, the staff concludes that the factors of safety are based on the actual AP1000 basemat loads due to deadweight, flood, groundwater, wind, tornado, and earthquake. To facilitate the staff’s review, Westinghouse is requested to provide the numerical values of the basemat loads used in the above calculations, for both the AP1000 and AP600, and to describe any basemat design changes, from the AP600 to the AP1000, necessary to meet the minimum factor of safety requirements listed in Table 3.8.5-1.

220.019

Subsection 3.8.5.5, “Structural Criteria,” provides Tier 2* information applicable to the design of shear reinforcement for the basemat below the auxiliary building. The criteria for the AP1000 appears to be a significant departure from the comparable Tier 2* criteria presented in the AP600 DCD and previously accepted by the staff. Therefore, Westinghouse is requested to provide (1) a detailed explanation of the differences between the new AP1000 criteria and the accepted AP600 criteria; and (2) the technical justification that a comparable level of safety will be achieved.

HISTORY OF PREVIOUSLY-ISSUED
REQUESTS FOR ADDITIONAL INFORMATION

Letter No.	Date issued	ADAMS Accession No.	RAI Nos.	Date of response	ADAMS Accession No.
1	6/26/2002	ML021780568	440.001 - 440.008	7/24/2002	ML022110430
2	8/16/2002	ML022280379	720.001		
3	8/27/2002	ML022390103	420.001 - 420.046, 435.001 - 435.015		
4	9/3/2002	ML022460356	620.001 - 620.043		
5	9/4/02	ML022470255	210.001 - 210.057		
6	9/5/02 Reissued 9/18/02	ML022480440, Reissued RAI ML022610042	440.009 - 440.148, 720.002 - 720.026		
7	9/19/02	ML022620026	260.001 - 260.003, 261.001 - 261.010, 471.001, 471.010, 472.001, 472.003		

Enclosure 2

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