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Your ref Docket No. 52-006
Our ref DCP/NRC1552

March 3, 2003

SUBJECT: Transmittal of Westinghouse Responses to US NRC Requests for Additional Information on the AP1000 Application for Design Certification

This letter transmits the Westinghouse revised responses to NRC Requests for Additional Information (RAI) regarding our application for Design Certification of the AP1000 Standard Plant. A list of the RAI responses that are transmitted with this letter is provided in Attachment 1. Attachment 2 provides the RAI responses.

Please contact me if you have questions regarding this submittal.

Very truly yours,

M. M. Corletti

M. M. Corletti
Passive Plant Projects & Development
AP600 & AP1000 Projects

/Attachments

1. Table 1, "List of Westinghouse's Responses to RAIs Transmitted in DCP/NRC1552"
2. Westinghouse Non-Proprietary Response to US Nuclear Regulatory Commission Requests for Additional Information dated February 2003

D063

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Attachment 1

ATTACHMENT 1

Table 1 "List of Westinghouse's Responses to RAIs Transmitted in DCP/NRC1552"
RAI 220.010, Revision 1 RAI 220.012, Revision 1 RAI 220.013, Revision 1 RAI 220.018, Revision 1

DCP/NRC1552

March 3, 2003

Attachment 2

AP1000 DESIGN CERTIFICATION REVIEW

Response to Request For Additional Information

RAI Number: 220.010 (Response Revision 1)

Question:

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 AP1000, compared to AP600.

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

Westinghouse Response:

The Westinghouse responses to RAI 230.006 and 230.007 provide the information requested. Further, Tables 3.7.2-1 to 3.7.2-7 of the DCD provide numerical values for frequency and accelerations. Both the AP1000 and AP600 will maintain a comparable level of safety which is based on the code criteria stress limits that are being used.

Design Control Document (DCD) Revision: (this revision was included in DCD Revision 3)

Revise fifth paragraph of subsection 3.8.3.5

The methods described in subsection 3.7.2 are employed to obtain the safe shutdown earthquake loads at various locations in the containment internal structures. The safe shutdown earthquake loads are derived from the **equivalent static** analysis of a three-dimensional, finite element model representing the entire containment internal structures.

PRA Revision:

None

NRC Additional Comments:

Westinghouse agreed to provide a revision to AP1000 DCD Table 3.8.3-2, which clarifies the specific analysis models and methods used for the seismic analysis of the AP1000 containment internal structures (CIS). Westinghouse indicated that frequencies and equivalent static accelerations for out-of-plane seismic analysis of the module walls and slabs are not available at this time. Westinghouse is expected to include this information in the final design calculations for the AP1000 module walls and slabs, which will be available for the staff audit when completed. The staff will make the determination of structural design adequacy of the AP1000 modules after review and evaluation of all pertinent DCD information, RAI responses, design summary report, and detailed design calculations.

Westinghouse Response: (Revision 1):

DCD Table 3.8.3-2 will be revised as indicated.

The frequencies and equivalent static accelerations used for out-of-plane seismic analysis of the module walls and slabs will be available for the staff audit in the final design calculations.

Design Control Document (DCD) Revision:

Revise Table 3.8.3-2 as shown on the next page.

PRA Revision: None

Table 3.8.3-2

SUMMARY OF CONTAINMENT INTERNAL STRUCTURES MODELS AND ANALYSIS METHODS

Computer program and Model	Analysis Method	Purpose	Concrete Stiffness [(1)]
3D ANSYS finite element of containment internal structures fixed at elevation 98′ 0"	Equivalent static analysis	To obtain the in-plane **and out-of-plane** seismic forces for the design of floors and walls	Monolithic Case 1
3D ANSYS finite element of containment internal structures fixed at elevation 98′ 0"	Static analyses	To obtain member forces in boundaries of IRWST for static loads (dead, live, hydrostatic, pressure)	Monolithic Case 1
3D ANSYS finite element of containment internal structures fixed at elevation 98′ 0"	Static analyses	To obtain member forces in boundaries of IRWST for thermal loads	Cracked Case 3
The following AP600 analyses are used as background to develop the AP1000 design loads.			
3D ANSYS finite element of containment internal structures fixed at elevation 103′ 0"	Harmonic analyses	To evaluate natural frequencies potentially excited by hydrodynamic loads	Uncracked Case 2
	Time history analyses	To obtain dynamic response of IRWST boundary for hydrodynamic loads	Monolithic and cracked Cases 1 & 3

<u>Notes:</u>
1. See Table 3.8.3-1 for stiffness case description.

AP1000 DESIGN CERTIFICATION REVIEW

Response to Request For Additional Information

RAI Number: 220.012 (Response Revision 1)

Question:

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.

Westinghouse Response:

A. The reactor pressure vessel support system is described in subsections 3.8.3.1.1 and 5.4.10.2.1. The reactor vessel support is constructed to ASME, Subsection NF and is similar to the AP600 reactor vessel support.

The embedded steel in the AP600 design has been incorporated into the CA-04 structural module for the AP1000. This module is shown in sheet 4 of DCD Figure 3.8.3-14. As depicted in DCD Figure 3.8.3-4 and in sheet 4 of DCD Figure 3.8.3-14, a horizontal octagonal plate is included as a flange at the top of the CA-04 structural module. The ASME-NF reactor vessel support is bolted to this horizontal plate. Vertical loads are carried through the plate and resisted by bearing on the concrete. Tangential loads (horizontal loads normal to the cold leg nozzle) are transferred into the concrete through shear lugs and headed anchors welded to the underside of the horizontal plate at the top of the CA-04 module. Radial loads are small due to the sliding bearing between the reactor vessel and the support.

DCD Figure 3.8.3-4 and sheet 4 of DCD Figure 3.8.3-14 will be revised as shown in attached figures.

B. DCD Figure 3.8.3-5 will be revised as shown in attached figures to show details for the steam generator supports, comparable to the level of details in the AP600 DCD.

D. The steel reinforcement in the containment internal structures concrete base was shown in DCD Figure 3.8.3-7 in the original issue of the AP600 DCD to provide typical details about steel reinforcement for all structures. Typical details were subsequently added for each critical section in Appendix 3H making the typical details shown in Figure 3.8.3-7 unnecessary. The figure was deleted in the AP1000 DCD because the internals structure base mat is not a critical section. The AP1000 reinforcement is similar to the AP600 reinforcement.

Design Control Document (DCD) Revision:

Revise subsections 3.8.3.1.1 and 5.4.10.2.1 as shown below.

3.8.3.1.1.1 Reactor Vessel Support System

The reactor vessel is supported by four supports located under the cold legs, which are spaced 90 degrees apart in the primary shield wall. The supports are designed to provide for radial thermal growth of the reactor coolant system, including the reactor vessel, but they prevent the vessel from lateral and torsional movement. The loads are carried by the reactor vessel supports **to** embedded steel **plates of the CA-04 structural module which forms the inside face of** the primary shield concrete. Figure 3.8.3-4 shows the reactor vessel supports. **Sheet 4 of Figure 3.8.3-14 shows the CA-04 structural module.**

5.4.10.2.1 Reactor Pressure Vessel

The reactor vessel supports consist of four individual, air-cooled steel box structures located beneath the inlet nozzles (See Figure 3.8.3-4). The boxes are air-cooled to achieve a concrete design temperature of 200°F. To reduce heat transfer from the nozzle to the concrete, cooled air is baffled vertically through the support, and the heated air is vented at the top.
Vertical and horizontal loads are transmitted from the reactor vessel nozzle pad to the box structure through an integral "shoe" machined into the top of the box. The nozzle pad bears on permanently lubricated wear plates that allow radial thermal movements of the nozzle with minimal friction resistance to the movement. The vessel support boxes transfer loads from the reactor pressure vessel to vertical and horizontal embedments in the primary shield wall concrete.

Revise Figure 3.8.3-4 as shown in attached figure.
Revise Figure 3.8.3-14 (sheet 4 of 5) as shown in attached figures.
Add 4 sheets to Figure 3.8.3-5 as shown in attached figures.

PRA Revision:

None

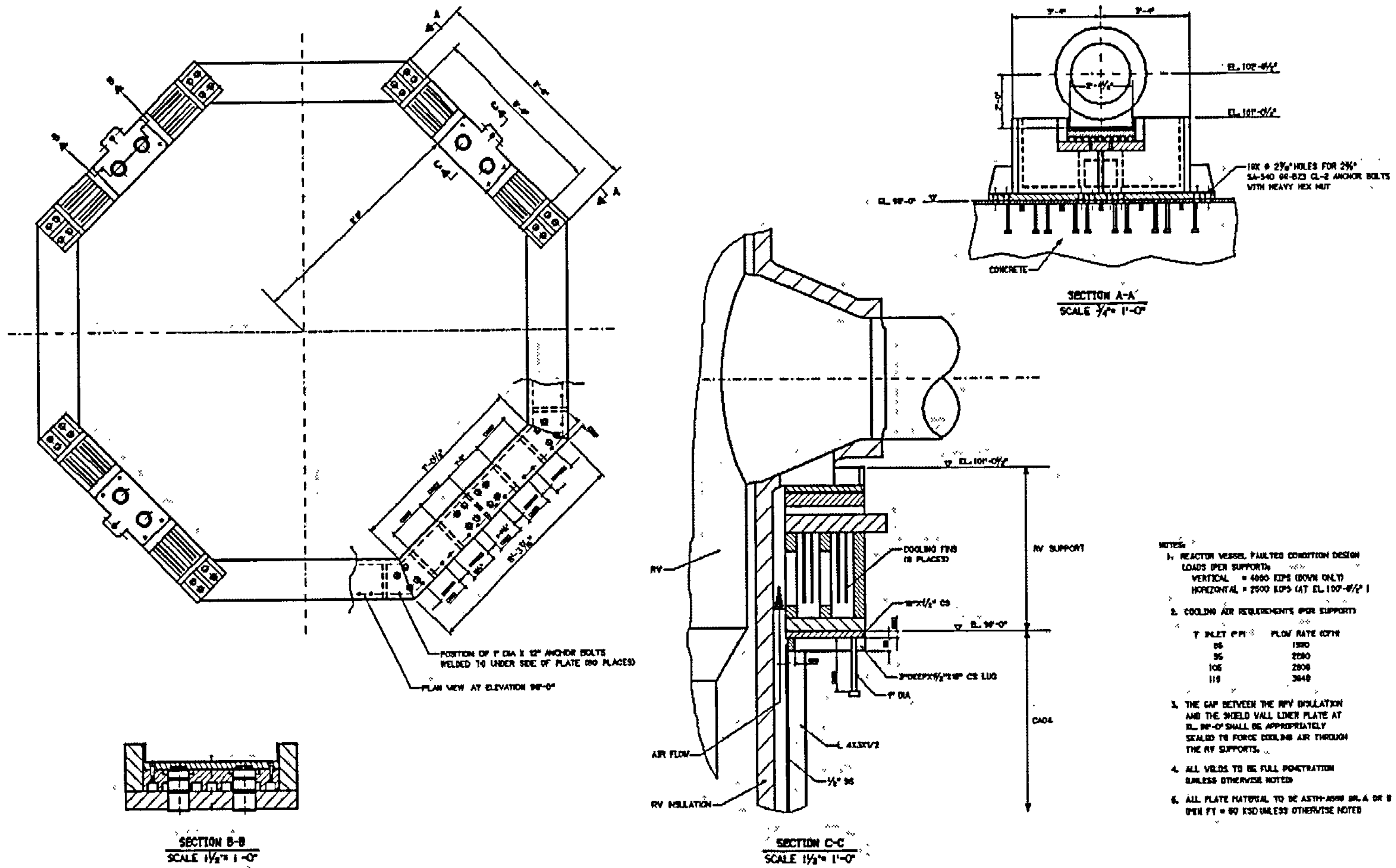
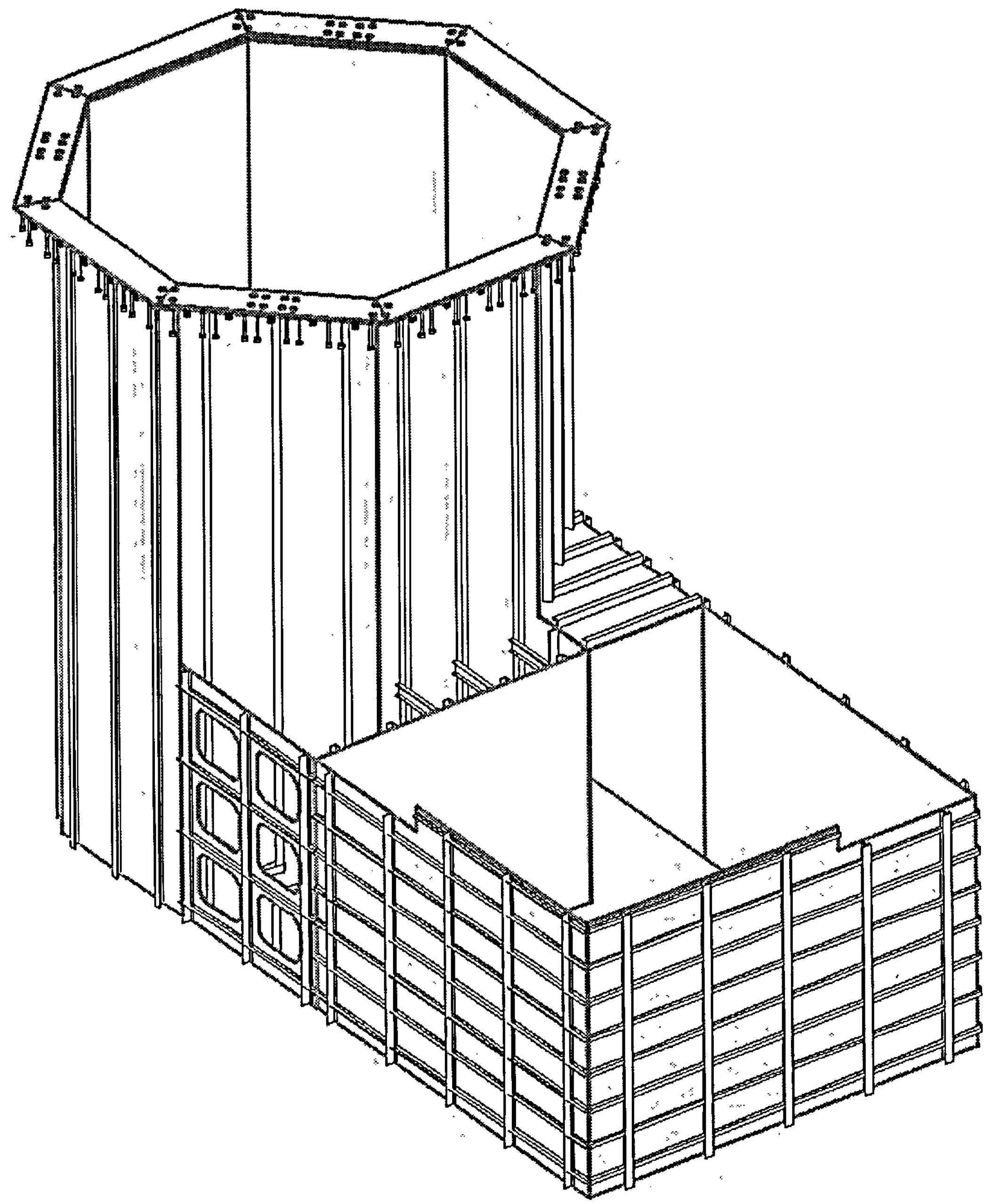
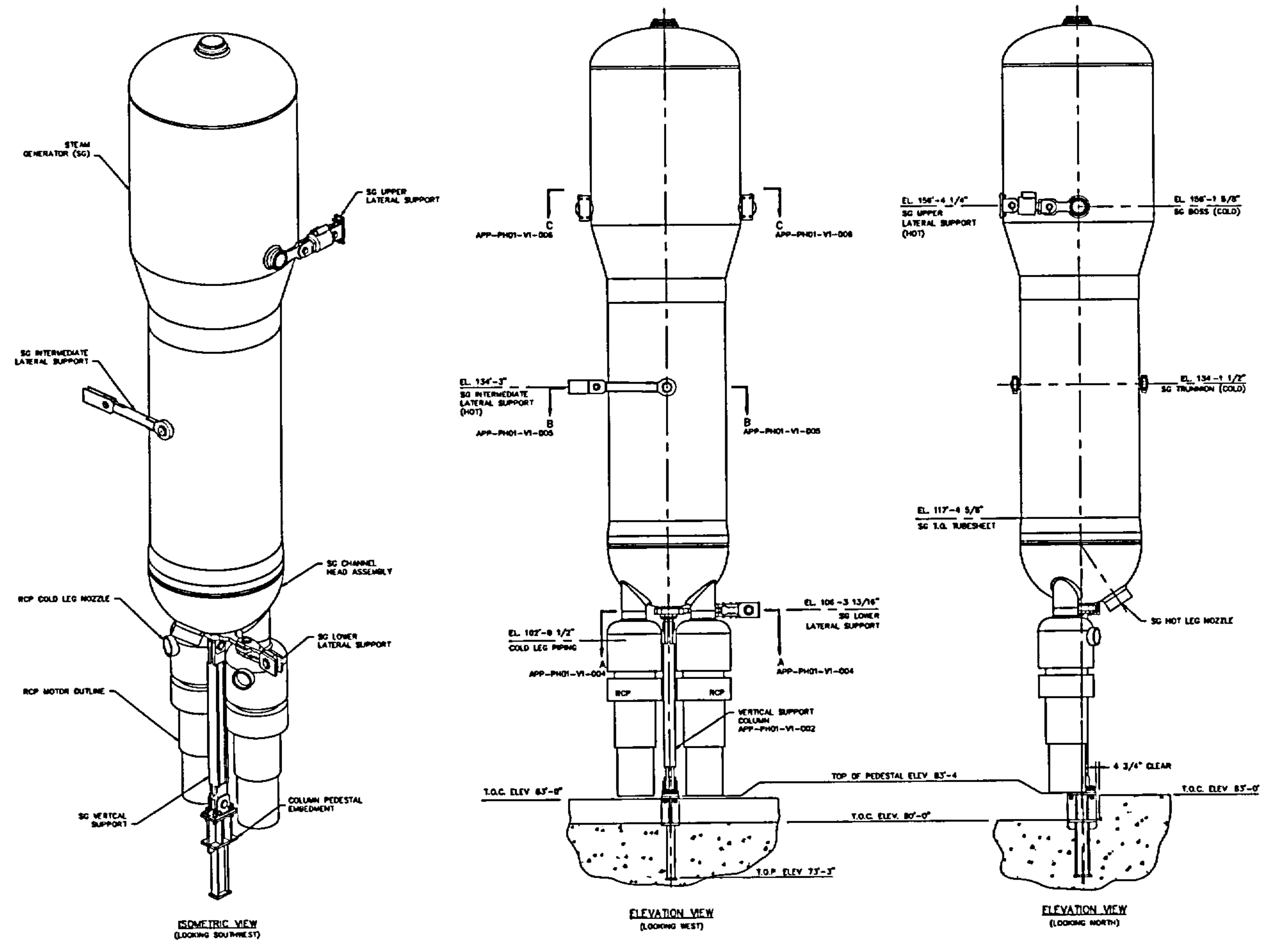


Figure 3.8.3-4
Reactor Vessel Supports



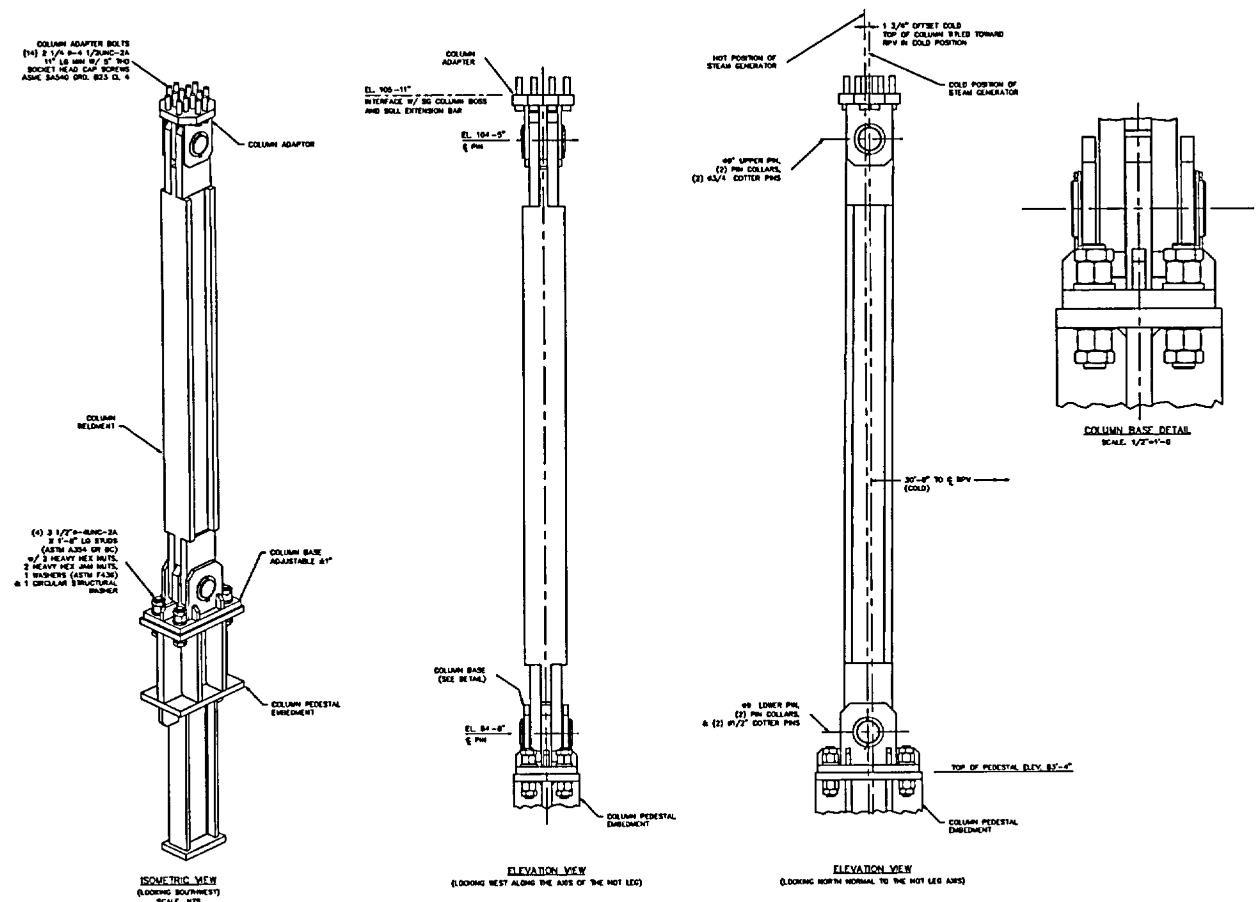
ISO VIEW LOOKING SOUTH WEST

Figure 3.8.3-14 (Sheet 4 of 5)
CA-04 Structural Module



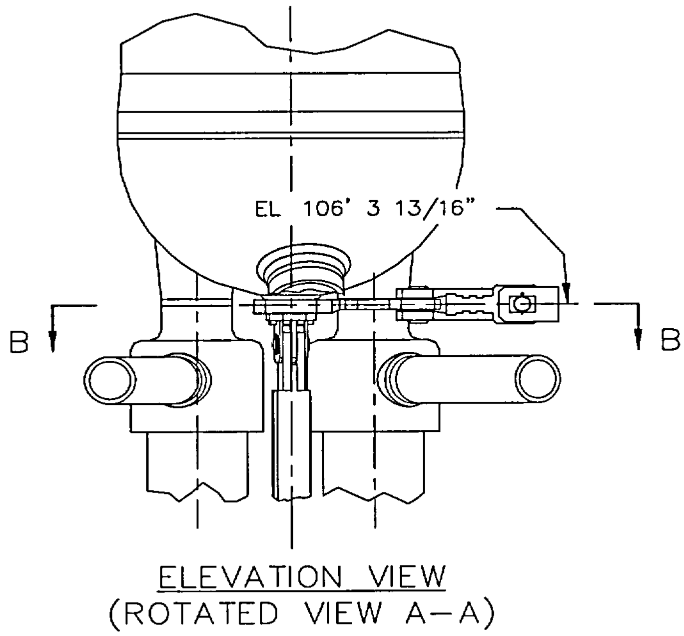
SG Support Assembly

Figure 3.8.3-5 (Sheet 1 of 5)
Steam Generator Supports

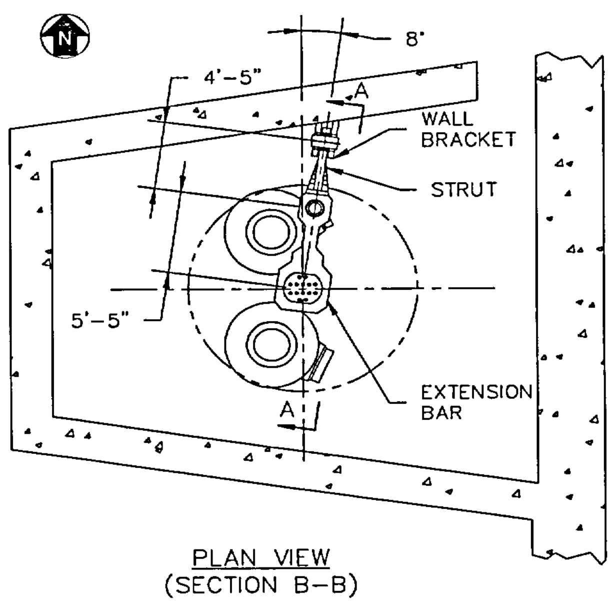


SG Vertical Support Column

Figure 3.8.3-5 (sheet 2 of 5)
Steam Generator Supports

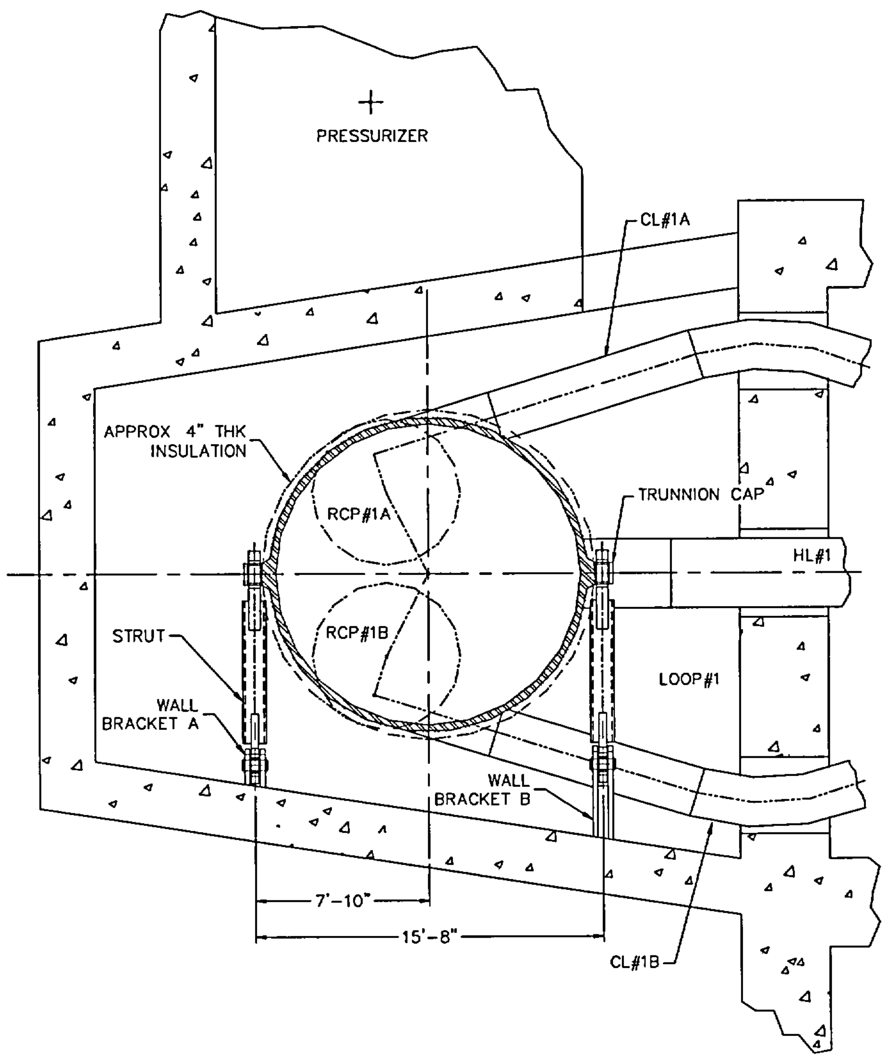


Lower Lateral Support Elevation View



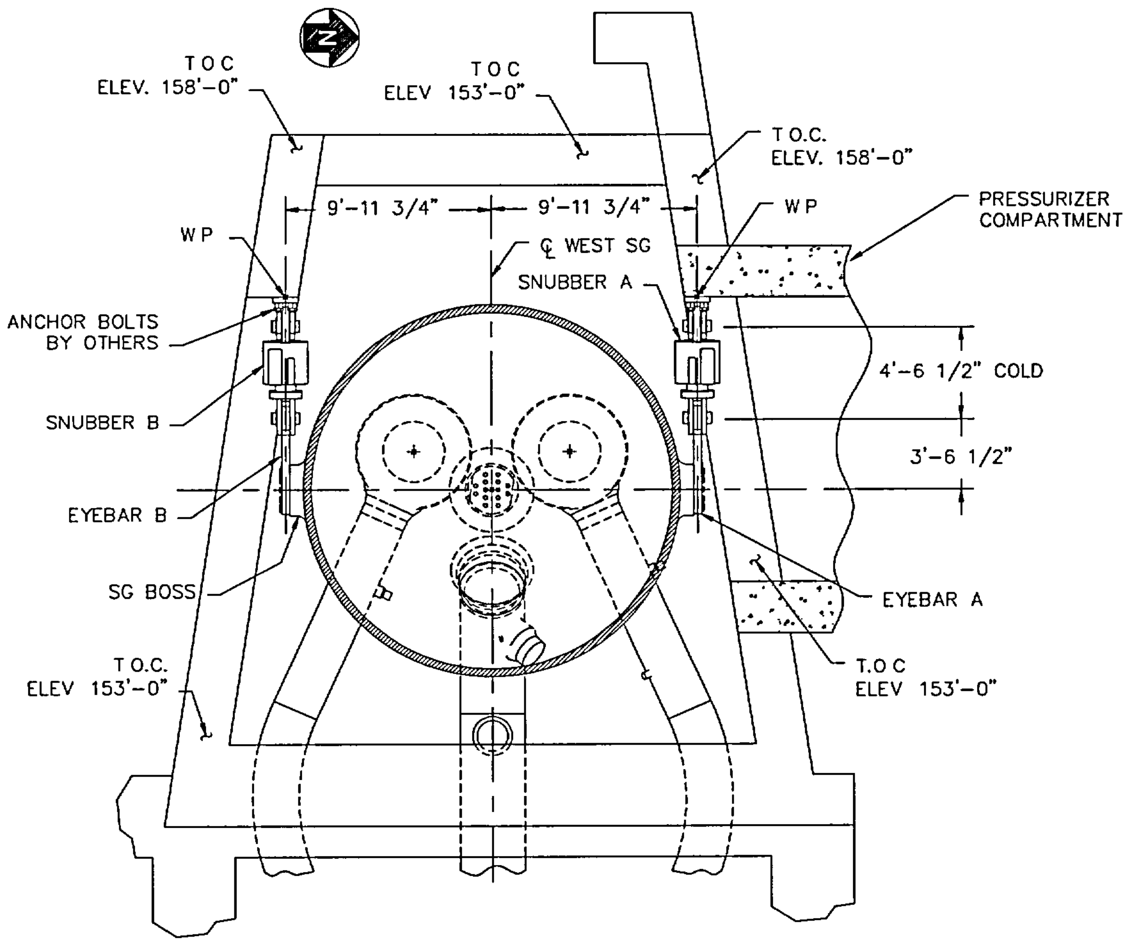
Lower Lateral Support Plan View

Figure 3.8.3-5 (sheet 3 of 5)
Steam Generator Supports



Intermediate Lateral Support

Figure 3.8.3-5 (sheet 4 of 5)
Steam Generator Supports



PLAN VIEW
[ELEV. 156'-1 5/8" (COLD)]

Upper Lateral Support

Figure 3.8.3-5 (sheet 5 of 5)
Steam Generator Supports

NRC Additional Comments:

The staff reviewed Westinghouse's response to this RAI provided at the meeting and found that the information is not complete to address the staff's concern. As a result of discussion, Westinghouse agreed to provide additional information about the anchorage of steam generator supports to module walls and also to provide larger, more easily readable copies of Figures 3.8.3-4 and 3.8.3-5 (sheets 1 and 2).

Westinghouse Response: (Revision 1):

DCD subsection 3.8.3.1.1.2 is revised as shown below to provide additional information about the anchorage of the steam generator supports to module walls and adjacent structure. Figures 3.8.3-4 and 3.8.3-5 (sheets 1 and 2) have been included in Revision 3 of the DCD as 11" x 17" pages and are easily readable.

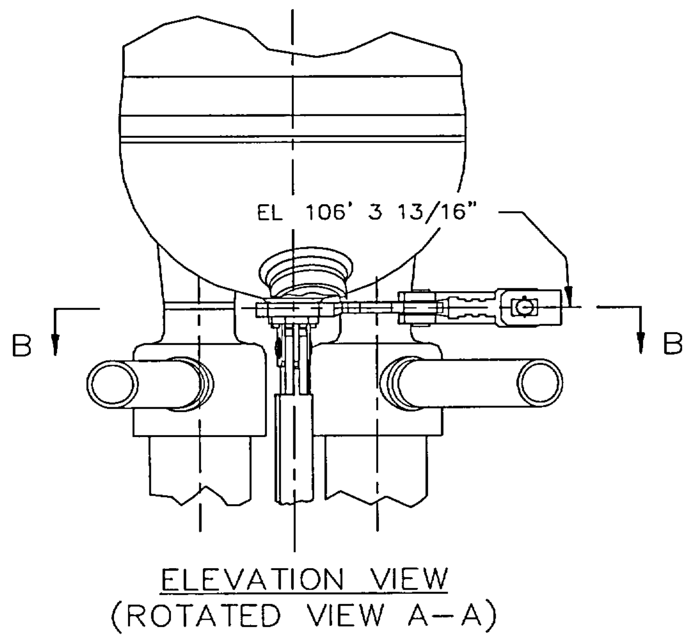
Design Control Document (DCD) Revision:

Add a new paragraph at the end of subsection 3.8.3.1.1.2 as follows:

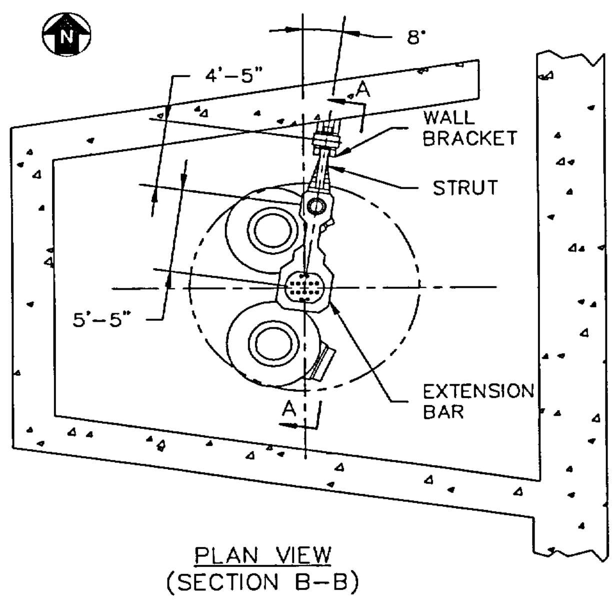
The steam generator supports are anchored using anchor bolts or steel weldments embedded in the concrete designed in accordance with Appendix B of ACI 349. The lower portion of the column pedestal is embedded in the concrete as shown on sheet 1 of Figure 3.8.3-5 and transfers the vertical load into the reinforced concrete basemat. The lower and intermediate horizontal supports are located so that the loads are transferred into the plane of the adjacent floor. The upper supports are located so that the loads are transferred into the plane of the steam generator compartment walls.

PRA Revision:

None



Lower Lateral Support Elevation View



Lower Lateral Support Plan View

Figure 3.8.3-5 (sheet 3 of 5)
Steam Generator Supports

AP1000 DESIGN CERTIFICATION REVIEW

Response to Request For Additional Information

RAI Number: 220.013 (Revision 1)

Question:

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 Regulatory Guide 1.142 [TITLE] in Appendix 1A." The staff notes that this statement and the discussion in Appendix 1A are <u>not</u> 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.

Westinghouse Response :

ACI 349 is substantially based on ACI 318 "Building Code Requirements for Reinforced Concrete". ACI 318 is revised on a three or four year cycle with revised codes issued in 1992, 1995, 1999 and 2002. ACI 349-97 was based on the 1992 edition of ACI 318. Revisions were made in ACI 349-01 to make ACI 349 consistent with the 1995 edition of ACI 318. All revisions are marked by a side bar in ACI 349-01. Some of the ACI 318-95 provisions, which have now been included in ACI 349-01, are specifically mentioned in the Regulatory Guide 1.142 endorsing ACI 349-97 and were also specifically considered in the AP600 design. Thus, these changes do not affect the AP1000 design.

ACI 349-01 incorporated substantial changes from ACI 349-97 in Appendix B for anchoring to concrete. This appendix is covered in Draft Regulatory Guide DG-1099.

AP1000 DESIGN CERTIFICATION REVIEW

Response to Request For Additional Information

The changes between ACI-349-97/RG 1.142 and ACI-349-01/Westinghouse Position do not affect the AP1000 design.

Subsection 3.8.4.5.1 is being revised to identify the applicable supplemental requirements for ACI-349 that are given in the position on Regulatory Guide 1.142. These will be designated Tier 2*.

Design Control Document (DCD) Revision: (this is included in DCD Revision 3)

Correct typographical errors In Appendix 1A, pages 1A-52 and 1A-53, in relation to C.6 and C.15.

C.6	ACI 349-97, Section 9.2.1	Conforms	
C. 15		Conforms	The provisions in Section 11.6 of ACI 349-01 are the same as those in ACI 318-99 (Reference 46).

Revise subsection 3.8.4.5.1 Supplemental Requirements for Concrete Structures

[*Supplemental requirements for ACI-349-01 are given in the position on Regulatory Guide 1.142 in Appendix 1A.* ***The structural design meets the supplemental requirements identified in Regulatory Positions 2 through 8, 10 through 13, and 15.***]*

[*Design of fastening to concrete is in accordance with ACI 349-01, Appendix B.*]*

PRA Revision:

None

Westinghouse Response (Revision 1):

Use of ACI 349-01 in the design of AP1000 structures has identified a provision in the code that was incorrectly included from the ACI 318-95 code. A revision is shown below for inclusion in the DCD identifying this exception to ACI 349-01. Paragraph 21.6.6.1 of ACI 349-01 states:

> **21.6.6.1** —Boundary elements shall be provided at boundaries and edges around openings of structural walls when the maximum extreme fiber compressive stress, corresponding to factored forces including earthquake effect, exceeds $0.2f_c'$, unless the entire wall is reinforced to satisfy 21.4.4.1 through 21.4.4.3. The boundary element shall be permitted to be discontinued where the calculated compressive stress is less than $0.15f_c'$. Stresses shall be calculated for the factored forces using a linearly elastic model and gross section properties.

This paragraph in ACI 349-01 (and paragraph 21.6.5.1 of ACI 349-97) is based on similar requirements in ACI 318-95 for boundary elements when the compressive stress exceeds 0.2 f'_c. The ACI 318 paragraph is similar in 318-95, 318-99 (paragraph 21.6.6.3) and 318-02 (paragraph 21.7.6.3). ACI 318 applies to structures for which the design forces are determined on the basis of energy dissipation in the nonlinear range of response. Seismic design loads are specified according to ASCE 7 or the UBC using a response modification factor that reduces the seismic input to account for the energy loss. The response modification factor is 4.5 for reinforced concrete shear walls in Table 9.5.2.2 of ASCE 7-95. It is 4 for ordinary reinforced concrete shear walls and 5 for special reinforced concrete shear walls in Table 9.5.2.2 of ASCE 7-98. The commentary to ACI 318-02 states that "the compressive stress of 0.2 f_c' is used as an index value and does not necessarily describe the actual state of stress that may develop at the critical section under the influence of the actual inertia forces for the anticipated earthquake intensity." Thus, the requirement for special transverse reinforcement in the boundary elements is intended for those cases where the elastic demand exceeds f'_c, and therefore, for the AP1000 plant, f'_c should be used since the seismic input has not been reduced to account for the energy loss. It is noted that the value of 0.2 f_c' is under review by the ACI code committee.

Design calculations for the shield building cylindrical wall show large areas of the wall where the compressive stress in concrete exceeds 0.2 f_c'. This includes the location of the openings for the equipment hatches and air locks. Compressive stresses are below 0.5 f_c'. Seismic response would be elastic at this level of stress and it is not necessary to provide additional transverse reinforcement on the assumption of non-linear response.

Design Control Document (DCD) Revision:

Revise subsection 3.8.4.5.1 Supplemental Requirements for Concrete Structures

> [*Supplemental requirements for ACI-349-01 are given in the position on Regulatory Guide 1.142 in Appendix 1A. The structural design meets the supplemental requirements identified in Regulatory Positions 2 through 8, 10 through 13, and 15.*]*

*[Design of fastening to concrete is in accordance with ACI 349-01, Appendix B.]**

[The index value specified for definition of boundary elements in paragraph 21.6.6.1 of ACI 349-01 is increased from 0.2 f_c' to 1.0 f_c' since the seismic member forces are based on elastic analyses and have not been reduced to reflect energy loss.]*

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Response to Request For Additional Information

RAI Number: 220.018 (Response Revision 1)

Question:

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 AP600 to AP1000, necessary to meet the minimum factor of safety requirements listed in Table 3.8.5-1.

Westinghouse Response:

The plan dimensions of the Nuclear Island for the AP1000 plant are the same as for the AP600 plant. The Basemat design is the same for the AP1000 and AP600. The AP1000 shield building and steel containment are 25' 6" higher. Given below is a summary of pertinent loads for the AP600 and AP1000 plants.

The weight and center of gravity (in the plant coordinate system) are provided in the following table for both the AP1000 and AP600 plants.

Weight

	AP1000	AP600
Weight	280,715 kips	255,380 kips
Xcg	992.34'	992.315'
Ycg	986.45'	985.632'
Zcg	125.14'	117.426'

The buoyant force, lateral forces due to active and passive soil pressures, and overburden pressure are given in the table below. They are the same for the both the AP600 and AP1000 plants.

Hydrodynamic and Soil Pressures

Buoyant Force	Vertical	74,990 kips
Active Soil Pressure Force	North-South	2,906 kips
Active Soil Pressure Force	East-West	4,621 kips
Passive Soil Pressure Force	North-South	39,574 kips
Passive Soil Pressure Force	East-West	62,925 kips
Surcharge Pressure Force	North-South	1,927 kips
Surcharge Pressure Force	East-West	3,805 kips

The seismic reactions at elevation 60.5' for the AP1000 and AP600 plants are given in the tables below.

AP1000 Seismic Loads
Units: kips & ft-kip

Moments Relative to Center of Containment		Moments Relative to End Boundaries of NI Basemat	
Seismic Reactions	**Absolute Value**	**Seismic Reactions**	**Absolute Value**
Vertical	101,495	Moment Line 1	14,903,017
Shear NS	99,814	Moment Line 11	14,791,352
Moment about NS	8,547,756	Moment Line I	12,639,190
Shear EW	93,516	Moment West Side of Shield Building	13,644,293
Moment about EW	10,662,959		

AP600 Seismic Loads
Units: kips & ft-kip
Moments Relative To Center Of Containment

Seismic Reactions	Hard Rock
Axial	89,234
Shear NS	91,368
Moment about NS	7,715,877
Shear EW	91,868
Moment about EW	7.478,927

The factors of safety associated with the AP1000 plant for the stability evaluation are given in Table 3.8.5-2, which will be revised in the DCD as shown below. The minimum required factors of safety for overturning, sliding, and flotation of structures are given in Table 3.8.5-1.

The factors of safety associated with the AP1000 and AP600 plants from the stability evaluation for the hard rock case are given in the table below.

FACTORS OF SAFETY FOR FLOTATION, OVERTURNING AND SLIDING OFNUCLEAR ISLAND STRUCTURES

Environmental Effect	AP1000	AP600
Flotation		
High Ground Water Table	3.7	3.4
Design Basis Flood	3.5	3.2
Sliding		
Design Wind, North-South	18.4	> 12.5
Design Wind, East-West	14.0	> 9.5
Design Basis Tornado, North-South	10.3	> 6.9
Design Basis Tornado, East-West	8.6	> 6,1
Safe Shutdown Earthquake, North-South	1.25	1.2
Safe Shutdown Earthquake, East-West	1.5	1.3
Overturning		
Design Wind, North-South	~~45.5~~ **51.7**	62.4
Design Wind, East-West	28.0	24.8
Design Basis Tornado, North-South	~~15.6~~ **17.7**	18.1
Design Basis Tornado, East-West	9.6	8.7
Safe Shutdown Earthquake, North-South	1.75	2.0
Safe Shutdown Earthquake, East-West	1.2	1.2

AP1000 DESIGN CERTIFICATION REVIEW

Response to Request For Additional Information

Design Control Document (DCD) Revision: *this revision was included in Revision 3*

Revise Table 3.8.5-2 as follows:

FACTORS OF SAFETY FOR FLOTATION, OVERTURNING AND SLIDING OF NUCLEAR ISLAND STRUCTURES

HARD ROCK CONDITION

Environmental Effect	Factor of Safety [(1)]
Flotation	
High Ground Water Table	3.7
Design Basis Flood	3.5
Sliding	
Design Wind, North-South	18.4
Design Wind, East-West	14.0
Design Basis Tornado, North-South	10.3
Design Basis Tornado, East-West	8.6
Safe Shutdown Earthquake, North-South	1.25
Safe Shutdown Earthquake, East-West	1.5
Overturning	
Design Wind, North-South	~~45.5~~51.7
Design Wind, East-West	28.0
Design Basis Tornado, North-South	~~15.6~~17.7
Design Basis Tornado, East-West	9.6
Safe Shutdown Earthquake, North-South	1.75
Safe Shutdown Earthquake, East-West	1.2

Notes:
1. Factor of safety is calculated for a site with rock below the underside of the base mat (elevation 60'-6") and soil adjacent to the exterior walls above this elevation

PRA Revision:

None

NRC Additional Comments:

In its response, Westinghouse provided the listings of total mass, foundation/wall soil design loads, location of mass centers of gravity (cg's) and the calculated safety factors. However, the following issues need to be addressed.

(A) The effects of potential lift-off of the basemat on building response and floor response spectra have not been considered in the evaluation. Westinghouse agreed to consider such potential lift-off effects and perform nonlinear time history evaluations using simplified structural models of the basemat, hard rock springs and structural stick models of the NI.

(B) When the modal time history analyses, using two components of the ground motion time history (H1 and H2 motions) as input, were performed for the NI, the building responses (member forces and floor response spectra) were calculated by algebraical combination technique at each time step. Since the relation of positive directions of the ground motions to the NI is not defined, this procedure does not necessarily result to the maximum responses. Westinghouse agreed to consider this effect by changing the sign of one of the two ground motion components and perform seismic analyses, using the same structural models, to determine the final responses.

Westinghouse also committed that the results of these analyses will be available for review during the next design calculation audit.

Westinghouse Response: (Revision 1):

(A) The effects of potential lift-off of the basemat on building response and floor response spectra will be addressed in the response (revision 1) to RAI 241.001.

(B) The significance of the input direction was investigated by changing the sign of one of the ground motion components (HOR1 in the north south direction) and repeating the time history seismic analyses. Table 220.018-1 compares the maximum absolute accelerations at the edges of the auxiliary and shield buildings for the two directions of horizontal seismic input. Tables 220.018-2 and 220.018-3 provide comparisons of the member forces. The responses for the two cases are similar with differences of less than 10% in most responses. The torque increases by 16% at the elevation of the PCS tank on the shield building roof. The magnitude is small in both cases, and would not affect the structural design. The torque decreases by 25% between elevations 66' 6" and 82' 6".

Design Control Document (DCD) Revision:

DCD Revision 3 incorporates the changes identified in the original response to this RAI. There are no additional revisions proposed in this revision to the response.

PRA Revision:
None

Table 220.018-1
MAXIMUM ABSOLUTE ACCELERATIONS AT EDGES

Elevation (ft)	HOR1 positive			HOR1 negative			Ratio		
	Ax	Ay	Az	Ax	Ay	Az	AX	AY	AZ
333.13	1.418	1.801	1.522	1.436	1.794	1.562	1.013	0.996	1.026
295.23	1.069	1.312	1.490	1.156	1.204	1.529	1.081	0.918	1.026
265.00	0.919	1.004	0.778	0.947	0.941	0.771	1.030	0.937	0.991
242.50	0.840	0.882	0.733	0.865	0.839	0.742	1.030	0.951	1.012
220.00	0.773	0.811	0.659	0.780	0.780	0.706	1.009	0.962	1.071
200.00	0.700	0.753	0.604	0.714	0.704	0.658	1.020	0.935	1.089
179.56	0.648	0.757	0.572	0.654	0.721	0.595	1.009	0.952	1.040
164.51	0.617	0.735	0.544	0.622	0.704	0.561	1.008	0.958	1.031
153.98	0.587	0.711	0.521	0.594	0.675	0.552	1.012	0.949	1.060
134.87	0.548	0.656	0.654	0.557	0.628	0.643	1.016	0.957	0.983
116.50	0.462	0.538	0.567	0.469	0.527	0.523	1.015	0.980	0.922
99.00	0.384	0.448	0.451	0.381	0.420	0.428	0.992	0.938	0.949
81.50	0.331	0.349	0.322	0.327	0.345	0.326	0.988	0.989	1.012
66.50	0.300	0.300	0.298	0.300	0.299	0.298	1.000	0.997	1.000
						Max ratio	1.081	0.997	1.089
						Min. ratio	0.988	0.918	0.922

Table 220.018-2

MEMBER FORCES
AUXILIARY AND SHIELD BUILDING

AXIAL AND SHEAR FORCES (x10^3 Kips)

			HOR1 Positive			HOR1 Negative			Ratio		
Elem	Elev	Elev	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear
303	295.23	333.13	2.78	6.01	7.74	2.83	6.30	7.67	1.018	1.048	0.991
301	265	295.23	15.86	15.47	16.64	16.12	16.15	16.58	1.016	1.044	0.996
38	242.5	265	19.07	21.62	22.47	18.71	22.74	22.38	0.981	1.052	0.996
37	220	242.5	21.18	24.85	25.23	20.88	26.22	25.13	0.986	1.055	0.996
36	200	220	23.07	27.47	27.09	22.83	29.00	27.00	0.990	1.056	0.997
35	179.56	200	24.72	29.60	28.27	24.54	31.30	28.20	0.993	1.057	0.998
34	164.51	179.56	26.04	22.16	22.33	25.89	23.02	21.67	0.994	1.039	0.970
33	153.98	164.51	28.14	22.18	18.79	28.11	22.88	19.10	0.999	1.032	1.016
32	145.37	153.98	30.15	14.78	13.00	29.96	15.08	12.86	0.994	1.020	0.989
31	134.87	145.37	31.75	17.06	14.33	31.60	17.35	14.21	0.995	1.017	0.992
7	116.5	134.88	37.55	45.18	36.44	37.31	47.14	36.71	0.994	1.043	1.007
6	106.17	116.5	43.27	51.01	43.30	43.01	52.94	44.10	0.994	1.038	1.018
5	99	106.17	45.75	52.71	45.27	45.50	54.68	46.19	0.995	1.037	1.020
4	91.5	99	52.69	19.35	18.98	52.63	19.99	19.46	0.999	1.033	1.025
3	81.5	91.5	56.99	21.69	21.64	56.90	22.27	22.04	0.998	1.027	1.018
2	66.5	81.5	61.70	13.70	12.99	67.94	13.93	13.68	1.101	1.017	1.053
1	60.5	66.5	84.13	47.30	52.58	87.61	48.33	53.70	1.041	1.022	1.021
							Max ratio		1.101	1.057	1.053
							Min. ratio		0.981	1.017	0.970

Table 220.018-3

MEMBER FORCES
AUXILIARY AND SHIELD BUILDING

MOMENTS (x10^3 Kips feet)

Elem	Elev	Elev	HOR1 Positive Torque	HOR1 Positive about N-S Axis	HOR1 Positive about E-W Axis	HOR1 Negative Torque	HOR1 Negative about N-S Axis	HOR1 Negative about E-W Axis	Ratio Torque	Ratio about N-S Axis	Ratio about E-W Axis
303	295.23	333.13	7.5	330.2	239.3	8.38	327.53	252.70	1.117	0.992	1.056
301	265	295.23	38.6	1063.7	826.9	44.80	1058.40	877.84	1.161	0.995	1.062
38	242.5	265	144.9	1565.6	1312.2	160.19	1558.03	1389.55	1.106	0.995	1.059
37	220	242.5	210.9	2185.6	1911.8	230.49	2175.79	2026.69	1.093	0.996	1.060
36	200	220	265.7	2771.7	2497.8	287.62	2761.44	2642.60	1.082	0.996	1.058
35	179.56	200	309.9	3388.1	3127.0	332.95	3380.78	3312.63	1.074	0.998	1.059
34	164.51	179.56	779.7	3753.8	3473.2	680.09	3737.81	3676.74	0.872	0.996	1.059
33	153.98	164.51	848.7	3992.0	3717.3	733.30	3974.86	3950.61	0.864	0.996	1.063
32	145.37	153.98	429.3	4125.9	3999.9	429.14	4098.19	4211.46	1.000	0.993	1.053
31	134.87	145.37	413.2	4271.7	4212.2	394.07	4246.27	4429.39	0.954	0.994	1.052
7	116.5	134.88	1087.2	5423.9	6289.2	1004.50	5472.30	5955.21	0.924	1.009	0.947
6	106.17	116.5	1162.6	5751.5	6885.4	1099.51	5801.51	6546.28	0.946	1.009	0.951
5	99	106.17	1201.3	5969.4	7281.7	1144.89	6019.56	6951.49	0.953	1.008	0.955
4	91.5	99	1385.0	6713.7	7703.2	1162.80	6584.52	7721.18	0.840	0.981	1.002
3	81.5	91.5	1486.9	6858.1	7911.3	1195.30	6723.39	7948.14	0.804	0.980	1.005
2	66.5	81.5	645.2	2203.6	3705.2	485.82	2217.11	3593.96	0.753	1.006	0.970
1	60.5	66.5	1467.0	3188.8	9520.8	1455.53	3146.12	9612.03	0.992	0.987	1.010
								Max ratio	1.161	1.009	1.063
								Min. ratio	0.753	0.980	0.947