February 24, 2011

MEMORANDUM TO: Eileen M. McKenna, Chief
AP1000 Projects Branch 2
Division of New Reactor Licensing
Office of New Reactors

FROM: William C. Gleaves, Sr. Project Manager ***/RA/***
AP1000 Projects Branch 2
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: SUMMARY OF A CATEGORY 1 PUBLIC MEETING HELD WITH WESTINGHOUSE ELECTRIC COMPANY REGARDING TIER 2* ITEMS PROPOSED IN AP1000 DESIGN CONTROL DOCUMENT, HELD IN CRANBERRY TOWNSHIP, PENNSYLVANIA ON JANUARY 10-14, 2011

The U.S. Nuclear Regulatory Commission (NRC) held a public meeting on January 10-14, 2011, with Westinghouse Electric Company (Westinghouse), at their headquarters building in Cranberry Township, Pennsylvania. The NRC's Office of New Reactors (NRO) staff and contractors met with Westinghouse staff, their contractors, other stakeholders, and the public to discuss specific Tier 2* requirements in the AP1000 Design Control Document (DCD) submitted as part of the design certification amendment.

The purpose of this meeting summary is to briefly describe the meeting, its participants, and to delineate the results. This meeting was noticed as a Category I public meeting in which a substantial portion of the meeting would be proprietary and therefore closed to the public. There were 18 persons in attendance at the meeting location, and 3 persons attending by conference call for the public part of the meeting. The meeting started at 1:20 p.m. EST on January 10, 2011, and ended at 1:30 p.m. on January 14, 2011.

Enclosed with this memorandum are materials relevant to this meeting. The enclosures are as follows: 1) the meeting attendee list and, 2) NRC's non-proprietary draft meeting preparatory materials referred to as "Table 1, Table 2, and Table 3."

CONTACT: Billy Gleaves, NRO/DNRL
(301) 415-5848

Discussion

This meeting was another in a series of follow-up meetings to discuss the contents of the DCD for the AP1000 Design Certification Amendment (DCA). The purpose of the meeting was to discuss Westinghouse's intended actions to address confirmatory items (CIs) identified in the NRC's Advanced Final Safety Evaluation. Specifically, the meeting was to address what steps Westinghouse intended to take to close the CI related to Tier 2* information in the DCD.

The meeting began with comments by NRC staff regarding the goal of the week was to address all the Tier 2* items identified in the draft meeting preparatory material during the week. Westinghouse agreed with NRC's general comments and discussed proposed ground rules for consistently identifying information in the DCD as Tier 2*. Following this discussion the staff and Westinghouse prioritized the discussion items and requested public comments.

Following the public comments, the public portion of the meeting, including the public conference bridge, was closed at 2:55 p.m.

Following a short break, the meeting was reopened as a closed meeting to discuss specific sections of the DCD and NRC's comments related to the Tier 2* nature for which the staff needed clarification to close the CI on the proposed AP1000 DCA structural and seismic review areas.

Conclusion

The staff thanked everyone for their participation and the public portion of the meeting ended at 2:55 p.m.

Docket No. 52-006

Enclosures:
As stated

Discussion

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Enclosures:
As stated

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OFFICE	LA:DNRL/NWE2	PM:DNRL/NWE2	BC:DNRL/NWE2
NAME	RButler*	BGleaves	EMcKenna
DATE	2/18/2011	2/24/2011	2/24/2011

OFFICIAL RECORD COPY

AP1000 Shield Building Closed Meeting
Public Meeting Attendance List
June 9-11, 2011

Name	Organization
Brian Thomas	NRC
John Ma	NRC
Eileen McKenna*	NRC
Rich Morante*	NRC/BNL
Billy Gleaves	NRC
Joe Braverman	NRC/BNL
Pravin Patel	NRC
Stanley Ritterbusch	Westinghouse
Don Lindgren	Westinghouse
Noele Creamer	Westinghouse
Narendra Prasad	Westinghouse
William LaPay	Westinghouse
Scott Altmayer	Westinghouse
Drew Murphy	Westinghouse
Jill Watson	Westinghouse
Mike Corletti	Westinghouse
JJ Deblasio	Westinghouse
Richard Orr	Westinghouse
Eddie Grant	NuStart/Excel
Don Moore	SNC
Tom Clements*	Public

*attended by teleconference

Enclosure 1

Draft NRC Meeting Preparatory Materials
“Table 1,” “Table 2,” and “Table 3”

Enclosure 2

"Table 1" Draft Assessment of AP1000 Tier 2* Information in DCD Rev.18 Section 3.8 & Appendix 3H

Unless otherwise noted, figs and tables associated with Tier 2* text should also be identified as Tier 2*. Existing Tier 2* info in DCD Rev. 18 should remain Tier 2*.

Notes:

a. Unless otherwise noted, figs and tables associated with Tier 2* text should also be identified as Tier 2*. Any existing Tier 2* info in DCD Rev. 18 should remain as Tier 2*.

b. Additional Tier 2* remarks/issues related to RAI responses are presented in Table 2 which follows this Table 1.

No.	DCD Section	Title	Remarks Regarding Tier 2* Information
1	3.8.2.1.1	General (under the main section - Steel Containment	The entire fourth paragraph (which references Figure 3.8.2-1) and the fifth paragraph, both of which provide containment dimensional information, should be Tier 2*.
2	3.8.2.1.2 through 3.8.2.1.7	Containment Vessel Support, Equipment Hatches, Personnel Airlocks, …	For each type of penetration and the vessel support, the text and the referenced 3.8.2-x figures should be Tier 2* as well as the figures themselves.
3	3.8.2.2	Applicable Codes, Standards, and Specifications	Third paragraph, which refers to applicable Regulatory Guides and Standard Review Plans, should be Tier 2*.
4	3.8.2.3	Loads and Load Combinations	(1) First paragraph, which refers to Table 3.8.2-1 for load combinations as well as the table, should be Tier 2*; (2) The reference to 10 CFR 50.34(f) and the use of the "peak LOCA pressure plus ..." should be corrected in accordance with the response to RAI 3.8.2-03 Rev.2, which indicates that 10 CFR 50.44 should be referenced in the DCD instead of 10 CFR 50.34(f) and the term "peak LOCA pressure" should be "hydrogen generated pressure loads from 100% fuel clad metal-water reaction."
5	3.8.2.4.1.1	Axisymmetric Shell Analyses	Most of this subsection and the associated figures and tables, which summarize the global containment analyses, should be Tier 2*.
6	3.8.2.4.1.2	Local Analyses	Most of this subsection and associated figures and tables, which summarize the local containment analyses, should be Tier 2*.
7	3.8.2.5	Structural Criteria	Entire two paragraphs, which identified the applicable ASME Code and stress limits, should be Tier 2*.
8	3.8.2.6	Materials, Quality Control, and Special Construction Techniques	(1) Entire subsection should be designated as Tier 2*; (2) First paragraph: Considering the mismatch of allowable stresses between SA738 Grade B and SA350 LF2, need to confirm how WEC design procedure addresses this mismatch.

9	3.8.2.7	Testing and In-Service Inspection Requirements	10 CFR Part 50, Appendix J, for leak rate testing, and 10 CFR 50.55a [ASME Section XI, Subsection NE, with enhancements], for ISI, should be specifically identified in this section of the DCD, and designated as Tier 2*. This Tier 2* designation does NOT expire at first fuel load.
10	3.8.3.2	Applicable Codes, Standards, and Specifications	(1) First and fifth bullets, the phrase "(refer to subsection 3.8.4.5 for supplemental requirements)" should be Tier 2*. These criteria supplement the ACI 349 and AISC-N690 Code requirements for design of concrete and steel structures, respectively; (2) A paragraph should be inserted and made Tier 2* similar to the next to the last paragraph in subsections 3.8.2.2 and 3.8.4.2, which refers to applicable Regulatory Guides and Standard Review Plans.
11	3.8.3.3	Loads and Load Combinations	First paragraph, which refers to subsection 3.8.4.3 and the associated tables, should be Tier 2*. The referenced subsection 3.8.4.3 and associated tables provide the loads and load combinations.
12	3.8.3.4	Analysis Procedures	Selected portions of the descriptions which summarize the analyses and the associated figures and tables should be Tier 2*. For example: Section 3.8.3.4 - second paragraph which refers to Table 3.8.3-2 and the use of 0.8 factor to account for concrete cracking; and fifth paragraph (including the 3 bullets) which discusses the three cases for considering the module stiffness as summarized in Table 3.8.3-1.
13	3.8.3.4.1	Seismic Analyses	First paragraph and the bullets (with the equations) that follow should be Tier 2*. These items describe the finite element model (FEM) including the development of the equivalent shell properties of the containment internal structural modules.
14	3.8.3.4.1.2	Stiffness Assumptions for Local Seismic Analyses…	First paragraph, which describes the FEM used for the local seismic analyses of the in-containment refueling water storage tank (IRWST), should be Tier 2*.
15	3.8.3.4.1.3	Damping of Structural Modules	Last sentence of first paragraph, which identifies the damping value for the structural modules and reinforced concrete structural elements, should be Tier 2*.
16	3.8.3.4.2.2	In-Containment Refueling Water Storage Tank Analyses	Second through fifth paragraph, which describe the FEM and analysis for hydrodynamic loading, should be Tier 2*.
17	3.8.3.5	Design Procedures and Acceptance Criteria	First through seventh paragraph, which summarize the design procedure and acceptance criteria, should be Tier 2*.

18	3.8.3.5.1	Reactor Vessel Support System	(1) WEC needs to explain why a new statement was inserted to state "Note the embedded anchor bolts are within the ASME jurisdictional boundary." This does not appear to be consistent with the definition of the jurisdictional boundary in the ASME Code; (2) Referenced Figure 3.8.3-4 was revised to remove details of the RPV support and anchorage to the structural modules. This information should be placed back into the DCD figure.
19	3.8.3.5.8.1	Structural Wall Modules	(1) Reference to Table 3.8.3-3, which identifies and provides the steel plate thicknesses for the critical sections, should be added and identified as Tier 2 *; (2) The reference to design information in Tables 3.8.3-4 through -6 should be Tier 2*.
20	3.8.3.6	Materials, Quality Control, and Special Construction Techniques	The basic materials/grades for the containment internal structures should be identified as Tier 2*.
21	3.8.3.8	Construction Inspection	The requirement for construction inspection to verify design information should be Tier 2*.
22	3.8.4.1.1	Shield Building	The third paragraph, beginning with "The overall configuration…" till the end of this subsection, should be Tier 2* because it provides key geometric and design information.
23	3.8.4.2	Applicable Codes, Standards, and Specifications	(1) First and seventh bullets, the phrase "(refer to subsection 3.8.4.5 for supplemental requirements)" should be Tier 2*. These criteria supplement the ACI 349 and AISC-N690 Code requirements for design of concrete and steel structures, respectively; (2) Next to the last paragraph, which refers to applicable Regulatory Guides and Standard Review Plans, should be Tier 2*.
24	3.8.4.3.2.1 & 2	Load Combinations, Steel Structures and Concrete Structures	The single paragraph in each of these subsections, which define the code and DCD Table for the applicable load combinations, should be Tier 2*.
25	3.8.4.4.1	Design and Analysis, Seismic Category I Structures	(1) Much of this section is already Tier 2* and the remaining paragraphs should also be identified as Tier 2* because they describe the analysis and design approach for the critical sections; (2) Description of the use of only the response spectrum analysis method for the SB is not correct since the equivalent static method was also used (see item identified in 3.7 list of items for more details); (3) Reference to Table 3.7.2-14 needs to be corrected because this table does not exist.
26	3.8.4.4.4	Below Grade Exterior Walls	This new subsection, which describes the analysis and design approach for the below grade exterior walls, should be Tier 2*.

27	3.8.4.5.1	Supplemental Requirements for Concrete Structures	Third paragraph, which added the statement for conformance with RG 1.199, Rev. 0 should also be Tier 2*.
28	3.8.4.5.4	Design Summary of Critical Sections	The list of 12 critical sections should be expanded to include: RC to SC connections, SB roof knuckle region (connection of SB roof to PCS Tank), and SB roof compression ring. This list of critical sections also needs to be revised to match the list in App 3H, Section 3H.5 and DCD Tier 1, Table 3.3-7 (see remarks/corrections under the row entry for DCD Tier 1, Table 3.3-1 below.)
29	3.8.4.6.1.1	Materials, Concrete	The first two sentences, which identify the compressive strengths of concrete for Seismic Category I structures and the SC members in the SB, should be Tier 2*.
30	3.8.4.6.1.2	Materials, Reinforcing Steel	First paragraph, which identifies the specific reinforcing steel type and grade, should be identified as Tier 2*. The material specification for the SB reinforcing steel should also be specified if different, and identified as Tier 2*.
31	3.8.4.6.1.3	Materials, Structural Steel	The key material types and grades used for the SC and other steel structures should be identified as Tier 2*.
32	3.8.4.8	Construction Inspection	For the SB and other structures, the requirement for construction inspection to verify design information should be Tier 2*.
33	3.8.5.1	Descriptions of the Foundations	First and second paragraph, which provide basemat thickness and elevation, as well as seismic gaps, should be Tier 2*.
34	3.8.5.2	Applicable Codes, Standards, and Specifications	The first sentence which identifies the applicable codes and standards should be Tier 2*.
35	3.8.5.3	Loads and Load Combinations	First paragraph, which identifies the loads and load combinations should be Tier 2*.
36	3.8.5.4.1	Analyses for Loads during Operation	(1) First paragraph refers to non existent Figures 3.7.2-1 and -2 for the FEM; (2) This subsection does not adequately capture the information from TR85 regarding exactly which model is used, how it was developed, what input loads were used (including reference to seismic acceleration table(s)) and analysis approach. Simply referencing Section 3.7.2.3, which in turn references App. 3G, both of which include so many different models, is not adequate. If reference is made to other subsections and appendices, they should be more specific so it is clear what models were used and how they were developed; (3) Why doesn't Section 3.8.5 describe the specific model(s) and analyses that are used to calculate the soil bearing demand that is presented in DCD Tier 1? This should be described in DCD 3.8.5, and if needed, reference to the model and figure(s) can be made to other sections in the DCD.

			The above information should be Tier 2*.
37	3.8.5.4.4	Design Summary of Critical Sections	The first sentence of the first paragraph, which identifies the design acceptance criteria, should be Tier 2*.
38	3.8.5.5	Structural Criteria	(1) First paragraph, first and last sentences, which identify the criteria for analysis and design and for stability evaluation, should be Tier 2*. (2) Second paragraph, the last phrase in the first sentence, which identifies RG. 1.199, Rev. 0 for design of concrete anchors, should also be Tier 2*. (3) There are editorial type and grammatical corrections that should be made (e.g., Section 3.8.5.5.1 refers to subsection 2.5.4.5.6 which does not exist); Therefore, WEC should review the entire 3.8 and App. 3H to correct other similar errors.
39	3.8.5.5.5	Seismic Stability Analysis	(1) Second paragraph: a more specific reference to a subsection in App. 3G is needed so it is clear what model was used for this stability evaluation. That subsection should include a summary/description of the model and a figure. (2) WEC needs to confirm the deflections of 0.12" without buoyant force and 0.19" with buoyant force considered because according to the staff's notes from the June 14, 2010 structural audits the re-analysis done during the audit resulted in deflections of 0.14" and 0.24" with and without the buoyant forces considered.
40	3.8.5.8	Construction Inspection	As identified above for Section 3.8.3.8 and 3.8.4.8, the requirement for construction inspection to verify design information should be Tier 2*.
41	3.8.6.1	Containment Vessel Design Adjacent to Large Penetrations	Designate the first paragraph as Tier 2*.
42	3.8.6.6	Construction Procedures Program	This Combined License Information item to require that COL holders develop a construction and inspection procedures to implement the commitments for the SC modules should be Tier 2*.

43	Table 3.8.3-3, and others	Definitions of Critical Locations and Thicknesses for...	This table as well as other tables in Section 3.8 should remove footnote "a" (i.e., "See Section 3.8.3.5.8 for reporting requirements for changes to Tier 2* information in this section") and replace it with the standard Tier 2* footnote, per remarks under Section 3.8.3.5.8, above.
44	Fig. 3.8.4-3	Developed View of SB …	No reference is made in Section 3.8 text to this figure. The previous reference to this figure was deleted in the DCD Rev. 18. In addition, the new revised figure is not legible; therefore, provide a legible figure that provides sufficient information.
45	Fig. 3.8.4-5	Shield Building Structure Key Areas	This figure, which was intended to be Tier 2*, should be identified as such in the title of the figure (i.e., italics, square bracket and star are missing).
46	Fig. 3.8.5-3	Radial/Circumferential/Longitudinal Reinforcement …	On the various sheets in this figure, the square boxes with dashed lines identifying the critical sections were deleted. Explain why.
47	3H.1	Introduction	(1) Third paragraph, the "twelve critical sections" should be expanded to include all 7 Shield Building "structural key areas" identified in Figure 3.8.4-5 of the DCD Rev.18. (2) Third paragraph only refers to the auxiliary building. This should be expanded to also include the shield building. The above information should be identified as Tier 2*.
48	3H.2	Description of Auxiliary Building	(1) This section should include a general description of the shield building in sufficient detail with references to figures. (2) The last sentence of this section should be expanded to include all 7 Shield Building "structural key areas" identified in Figure 3.8.4-5 of the DCD Rev.18. The above information should be identified as Tier 2*.
49	3H.3	Design Criteria	(1) The first sentence in the second paragraph should be revised since, according to DCD Rev. 18, Section 3.7 and the final response to RAI-TR85-27 dated September 23, 2010, equivalent static analyses are not used for the design of the auxiliary building, shield building (except for the tension ring, air inlet and W36 beam seat), and containment internal structure. Instead, seismic response spectrum analysis is performed to develop the seismic design loads for these buildings. (2) Third paragraph, first sentence, the use of the "GTSTRUDL" computer program is not consistent with DCD subsection 3.8.4.4.1, where only ANSYS is discussed. If GTSTRUDL is also utilized, then subsection 3.8.4.4.1 should be expanded to discuss the use of this program too. A description of the separate FEM and analysis approach for the SB roof and PCS tank should be included in the DCD. (3) Third paragraph, third sentence,

			the phrase "equivalent static accelerations" needs to be revised. The above information should be identified as Tier 2*.
50	3H.3.2	Seismic Input	The first sentence which identifies the SSE design response spectra in Figs. 3.7.1-1 and -2, should be Tier 2*.
51	3H.4	Seismic Analysis	In this section or in another appropriate section in Appendix 3H, a description should be provided for the three levels of analyses used for the shield building design (as discussed in Section 2.6 of the SB Report, Rev. 3). Level 1 for developing the building load magnitudes, Level 2 for determining member forces and deformations, and Level 3 for assessment of building design/margins. The information should include a description of the analysis models, analysis methods (e.g., equivalent static analysis or response spectra analysis), the seismic input, seismic force combination methods (e.g., SRSS or 100-40-40), results, etc., for the design of the 7 Shield Building "structural key areas" identified in Figure 3.8.4-5 of the DCD Rev.18. In those cases that would be appropriate, references to specific sections in the DCD that clearly contain the above information are acceptable. The above information should be identified as Tier 2*.

52	3H.5	Structural Design of Critical Sections	(1) The twelve critical sections discussed should be expanded to include all 7 Shield Building "structural key areas" identified in Figure 3.8.4-5 of the DCD Rev.18. This list of critical sections also needs to be revised to match the list in Section 3.8.4.5.4 and DCD Tier 1, Table 3.3-7 (see remarks/corrections under the row entry for DCD Tier 1, Table 3.3-1 below. (2) In this section or another appropriate section in Appendix 3H, a summary of the various structural elements, including material/grade, sizes, properties, welding information, selection of concrete cold joints, etc., should be provided for all major structural components (e.g., concrete, steel plates, steel shapes, tie bars, studs, reinforcements, etc.). Where appropriate reference can be made to figures where this information is provided. While some of this information is shown on some of the existing figures in App. 3H, there is additional information that is still needed. For welds, information should be provided which includes: v-notch fracture toughness and temperature, applicable welding codes and standards, processes and welding inspection criteria, acceptance standards for welds. The above information should be identified as Tier 2*.
53	3H.5.1.2	Wall at Column Line 7.3	(1) Should include discussions on design loads as in the other subsections (e.g. Subsection 3H.5.1.3). The information should be identified as Tier 2*.
54	3H.5.1.4	Wall at Column Line 11	A table containing the required reinforcement and provided reinforcement should be provided as presented for the other critical sections. This should include horizontal and vertical, at each face, and shear reinforcement. When this figure is included in APP. 3H, the corresponding figure(s) showing the FE locations should also be included. The information should be Tier 2*.

55	3H.5.1.5	Shield Building Cylinder at Elevation 180'-0"	(1) The heading in this subsection ("Shield Building Cylinder at Elevation 180'-0") should be revised to match the elevations identified for this critical section in subsection 3H.5 and DCD Tier 1 list of critical sections, which identifies this critical section as "shield building cylinder, elevation 160'-6" to elevation 266'-3." Note that as discussed in the remarks for DCD Section 3H.5 above and DCD Tier 1, Table 3.3-7 below, the elevation range will need to be revised, most likely to "100'-0" to 251'-6" excluding the RC/SC connections." (2) There is some confusion because the SB cylindrical wall is also presented in subsection 3H.5.6.1. Why is some of the information for the SB cylinder in 3H.5.1.5 and some information in 3H.5.6.1? It seems that the information in subsection 3H.5.1.5 should be placed in Section 3H.5.6.1. In that case, the title of subsection 3H.5.6 can be revised from "Shield Building Roof" to "Shield Building" and include all critical sections related to the SB in this subsection. Addressing this Item (2) will require expanding and improving the write-up so it is clear what models, analysis approach, input loadings, and results were obtained. (3) The results should include tables identifying the required reinforcement and provided reinforcement (i.e., plate thickness) for each direction, at each face, and for shear reinforcement (i.e., tier bars). In addition, figures including the overall configuration, identification of the various elements and dimensions (e.g., for plates, tie bars and spacing, studs and spacing), welding information for each of the components, material properties and ASTM designation for steel components, type and material properties for concrete, selection of concrete cold joints, etc., should be provided. The above information should be Tier 2*.
56	3H.5.5.1	West Wall of Spent Fuel Pool	Last paragraph indicates that "The steel plates are generally half inch thick. The plate thickness is increased close to the bottom of the gate through the wall where the opening results in high local member forces." This paragraph is the same as in DCD Rev. 15. However, the tables corresponding to these finite elements all indicate that the plate thicknesses are 0.5 inches. WEC should explain and/or fix this apparent inconsistency. The information should be identified as Tier 2*.

57	3H.5.6	Shield Building Roof	(1) The title of this section should be changed since this section contains design information of the whole shield building not just the roof. (2) The title of the referenced Figure 3.7.2-12, Sheet 7 of 12, should be revised to include elevation "El.329'-0." (3) The second paragraph should be expanded to include references to design detail figures for all 7 shield building "structural key areas" identified in Figure 3.8.4-5 of the DCD Rev.18. (4) A summary of construction sequence should be provided under section 3H.5.6. (5) Explain why the shield building reinforcement information provided in Table 11.1-1 of the Shield Building Report (Rev.3) do not exactly match the corresponding information provided in Table 3H.5-9 of DCD Rev.18 Appendix 3H. (6) In many of the reinforcement summary tables, the maximum required reinforcement should also be identified as Tier 2*. (7) The above information in items (4), (5), and (8) should be identified as Tier 2*.
58	3H.5.6.1	RC/SC Horizontal and Vertical Connections (example of key information not identified as Tier 2*)	(1) Design description and references to design summary tables and figures of the RC/SC connections should be included in this subsection. This should include figures showing all of the SC/RC connection locations including the elevations and dimensions showing the extent of these connections. These connections should include those between SC and RC portions within the SB cylinder (connections to the basemat, connections to auxiliary roof walls, etc.), SB to basemat, and SB to auxiliary bldg. In addition, figures should be provided to show the various details of the connections including plates, struts, welds, tie bars, gusset plates, nuts (including torque), dowel bars/reinforcements, mechanical connectors, and detailing of the RC connection portion. (2) Design summary tables and figures for RC/SC horizontal and vertical connections (at the SB base and the other regions that reach to about 149'-6") should be provided in Appendix 3H. Tables and figures that already exist in the Shield Building Report (Rev. 3) can be brought into DCD App. 3H (e.g., figures in Section 4 of the SB Report). The information described under this subsection should include tables identifying the required reinforcement and provided reinforcement (or plate thickness) for each direction, at each face, and for shear reinforcement (or tier bars). In addition, the figures should provide design details that include the information identified in the remarks for DCD Section 3H.5.1.5 above. The above information should be Tier 2*.

59	3H.5.6.2	SB Cylindrical Wall	(1) Explain why there are two sections for the SB cylindrical walls: Section 3H.5.1.5 and Section 3H.5.6.2. This was noted in the remarks under DCD Section 3H.5.1.5 above. (2) Both text in this section and Figure 3H.5-13 should provide design information/details such as wall thickness, plate thickness, stud sizes (diameter and length) and spacing, tie bar sizes and spacings, regions of the wall with various tie bar spacing, welding details (steel plate to steel plate, tie bars to steel plate, studs to steel plates, V-notch fracture toughness and temperature for steel plates welds), concrete type, material properties (concrete, steel plates, tie bars, studs), welding codes and processes, welding inspection criteria, ASTM specification for tie bars, studs and steel plates, basis for selection of cold joints, etc., (3) Tables for design summary of SB wall should be included in App. 3H and referenced in this section. Additional figures should be presented in Appendix 3H and referenced in this section. Tables and figures that already exist in the Shield Building Report (Rev. 3) can be brought into DCD App. 3H (e.g. Tables 3.2-4 through 3.2-7, Figure 3.2-4 and Figures D.1-1 through D.1-8). The information should include tables identifying the required reinforcement and provided reinforcement (or plate thickness) in each direction, at each face, and shear reinforcement (or tier bars). For additional items, see remarks in DCD Section 3H.5.1.5 above. The above information should be Tier 2*.

60	3H.5.6.3	Air Inlets and Tension Ring	(1) Text in this subsection and figures should include design information/details such as wall thickness, plate thicknesses, reinforcement and spacings, tie bar/stud/stiffener details (location, welds, sizes, spacings, material properties, ASTM specifications), welding details for steel plates/tie bars/studs (type, size, shop or in-situ welds, etc.), concrete type and regions of various type concrete, details of construction joints below the lower tension ring web (location, conformation to ACI code, preparation procedure, any dowels across the joint, etc.), number of air inlet openings, details of inlet pipes (sizes, spacing, inclination, materials, material properties, ASTM specifications, and how the air inlet pipes will be connected to the concrete and surface plates). Although some information is shown in Fig. 3H.5-11 sheets 3 and 4, it is not complete. Also, see remarks under this table entry corresponding to Fig. 3H.5-11 below. (2) Tables for the design summary of the air inlets and tension ring should be referenced in this section. Additional figures showing the connection of the SC wall and RC roof slab to tension ring should be provided in Appendix 3H. Figures that already exist in the Shield Building Report (Rev. 3) can be brought into DCD App. 3H. The information should include tables identifying the required reinforcement and provided reinforcement (or plate thickness) in each direction, at each face, and shear reinforcement (or tier bars). (3) Explain where is "this report" referred to in the last paragraph. The above information should be Tier 2*.
61	3H.5.6.4	SB Roof, Compression Ring, Knuckle Region, and PCS Tank	(1) Additional design descriptions and references to design summary tables and figures of the SB roof, compression ring, knuckle region, and PCS tank should be included in App. 3H and referenced in this subsection. (2) The information should include tables identifying the required reinforcement and provided reinforcement (or plate thickness) in each direction, at each face, and shear reinforcement (or tier bars). In addition, figures including the overall configuration, identification of the various elements, dimensions, welding, and reinforcement should be provided. Tables and figures that already exist in the Shield Building Report (Rev. 3) can be brought into DCD App. 3H (e.g., Figs. 6.1-5, 6.1-6, and D2-3). This information should be Tier 2*.
62	Table 3H.5-1	Nuclear Island: Design Temperatures for Thermal Gradient	This table as well as other tables in App. 3H should remove footnote "a" (i.e., "See Section 3H.1 for reporting requirements for changes to Tier 2* information in Appendix 3H") and

			replace it with the standard Tier 2* footnote, per remarks under Section 3H.1, Item (2), above.
63	Fig. 3H.5-9	Auxiliary Building Finned Floor	Sheet 2 of 3 does not show the design of the finned floor comparable to the same figure in DCD Rev. 15. This needs to be corrected.
64	Fig. 3H.5-11	Typical Design of Shield Building: Roof and Air Inlets, …	(1) Since this figure is Tier 2*, the term "Typical" should be removed from the title. This also needs to be addressed in a number of other figures where the term "Typical" is used. (2) On Sheet 2 of 7 of this figure, the title which identifies this as section "A-A" does not match with the designation of Section C-C shown on Sheets 1 and 3. (3) Sheet 3 of 7 needs to be reviewed by WEC and corrected (e.g., no welding identified, where is the use of cold joints addressed/identified). (4) SB Report, Fig. 11.3-2, plate thickness of the lower SC portion indicates 1" rather than 3/4. WEC should correct this figure. (5) Sheet 5 of 7 as well as other figures in App. 3H are not legible. WEC should review all figures in App. 3H and ensure that they are all legible, particularly where numerical and text information is given. (6) The title on sheet 7 of 7, which indicates that this figure is for "90-270 Degrees," should be corrected, since the previous sheet 6 of 7 is for the 90-270 degree view. (7) This figure does not provide sufficient information (e.g., legend to identify the various regions and connections). Figure 4.1-1 from the SB Report, Rev. 3, is more appropriate.
65	Figs. 3H.5-13, 14, & 15	Enhanced Shield Building Wall Panel Layout	These figures and any other figures that provide design related information in App. 3H should be Tier 2*.
66	DCD Tier 1; Section 3.3, Table 3.3-1	Definition of Wall Thicknesses for NI Bldgs., …	On Table 3.3-1, page 3.3-6: several dimensions/information do not seem to be correct. For example: SB Cylinder, Floor Elev. or Elev. Range, should be up to 251'-6 1/2" not "to 251'-6", concrete thickness for the lower entry in the row should be 3'-0" to 4'-6" not a constant 4'-6", plate thicknesses at RC/SC connections which are believed to be 1" are not reflected in the table, and several other items. The table would be clearer if separate rows were inserted to separate out the air inlet region and RC/SC connections.

67	DCD Tier 1; Section 3.3, Table 3.3-7	NI Critical Structural Sections	In Table 3.3-7, for the SB cylinder, elevation should be "100'-0" to 251'-6" excluding the RC/SC connections," and not 160'-6" to 266'-3". A line space should follow this entry to avoid confusion with the next critical section. Also, since a new entry for the SB air inlet and tension ring was included, the phrase "tension ring and columns between air inlets," from the line beginning with "Shield building roof, ...," should be removed. When corrections are made, this list should match the list of critical sections presented in DCD Tier 2, Section 3.8.4.5.4 and App. 3H, Section 3H.5.

"Table 2" Comments on Requests for Additional Information and Technical Reports

RAI #	SER Section	DCD Revision Required				Tech. Report Revn. Reqd.	Remark/Bases	Acceptable	
		DCD Revn. Req'd From SER Review	Tier 1	Tier 2	Tier 2*			Tier 2*	Overall
CI-RAI-SRP3.8.2-CIB-01	3.8.2.5	Yes	No	Yes	No	N/A	DCD Rev. 18 change is in accordance with RAI response: Acceptable.	N/A	Yes
CI-RAI-SRP3.8.2-SEB1-02	3.8.2.2.3	Yes	No	Yes	Yes	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	Yes	TBD
CI-RAI-SRP3.8.2-SEB1-03	3.8.2.3/ 3.8.2.4.1	Yes	No	Yes	No	N/A	DCD markup for Section 3.8 is **NOT** in accordance with RAI response: **NOT** Acceptable. On Page 3.8-6 of the DCD Rev.18, the markup in the fourth paragraph: (1) reference to 10 CFR 50.34(f) should be changed to 10 CFR 50.44, as requested by the follow up RAI Rev. 2 for RAI-SRP3.8.2-SEB1-03; (2) the phrase "peak LOCA pressure" is inconsistent with the accepted RAI response Rev. 2 to RAI-SRP3.8.2-SEB1-03, which indicates that the term "peak LOCA pressure" should be "hydrogen generated pressure loads from 100% fuel clad metal-water reaction."	N/A	No
CI-RAI-SRP3.8.2-SEB1-04	3.8.2.4	Yes	No	Yes	No	N/A	DCD markup for Section 3.8 is acceptable.	N/A	Yes
CI-RAI-SRP3.8.2-SEB1-05	3.8.2.6	Yes	No	Yes	No	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	N/A	TBD

CI-RAI-SRP3.8.3-SEB1-03	3.8.3.2	Yes	No	Yes	No	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	N/A	Yes
CI-RAI-SRP3.8.3-SEB1-04	3.8.3.3	Yes	No	Yes	No	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	N/A	Yes
CI-RAI-SRP3.8.3-SEB1-05	3.8.3.3	Yes	No	Yes	Yes	N/A	The staff reviewed the draft RAI revision 4A response, and found that the removal of the Tier 2* "change criteria" is acceptable; however, the following issues need to be addressed. **(1)** Proposed changes in the text, table and figures related to the changes noted on pages 6 and 7 of 34 in the RAI response are not acceptable (except the deletion of "or by lap splices where the reinforcement overlaps shear...") because these are basic design information for critical/representative sections and were included as Tier 2* in DCD Rev. 15. **(2)** For tables showing design parameters such as reinforcement provided, the locations of critical sections should be designated as Tier 2* information as in DCD Rev. 15; for example, the first three column entries of Table 3.8.3-3 should be Tier 2*. **(3)** For Table 3.8.3-4, explain why yield stress at design temperature was changed from DCD R18 markups. **(4)** Figure 3.8.3-8, Sheet 1 of 3, and Figure 3.8.3-15, Sheet 2 of 3, (a) regarding deleted weld locations and sizes, the design information should be included as	No	No

							in DCD Rev 15, (b) SST plate material designation should not be deleted (applicable to Figure 3.8.3-15). **(5)** See remark (3) under CI-RAI-SRP3.8.3-SEB1-07.		
CI-RAI-SRP3.8.3-SEB1-06	3.8.3.4	Yes	No	Yes	No	N/A	DCD markup is in accordance with RAI response: Acceptable.	N/A	Yes

CI-RAI-SRP3.8.3-SEB1-07	3.8.3.3	Yes	No	Yes	Yes	N/A	The staff reviewed the draft RAI revision 2A response, and found that the removal of the Tier 2* "change criteria" is acceptable; however, the following issues need to be addressed. **(1)** For tables showing design parameters such as reinforcement provided, the locations of the critical sections should be designated as Tier 2* information as in DCD Rev. 15; for example, the first three column entries of Table 3.8.5-3 should be Tier 2*. **(2)** An editorial typo needs to be fixed: Table 3.8.5-3, 1st row, 2nd column entry "Column line K to L and from Col. Line 11" is not complete (see DCD Rev.15). **(3)** Table 3.8.5-3, inserted the term "Minimum" for the provided reinforcement. Since there is also a maximum that is allowed per the ACI 349 Code, a footnote should be included to indicate that the maximum reinforcement limit in accordance with the ACI 349 Code still needs to be maintained. This remark applies to all DCD and DCD appendices where the term "Minimum" has been added.	No	No

CI-RAI-SRP3.8.4-SEB1-03	3.8.4.1	Yes	No	Yes	Yes	N/A	The staff reviewed the draft RAI revision 4A response, and found that the removal of the Tier 2* "change criteria" is acceptable; however, the following issues need to be addressed. **(1)** For tables showing design parameters such as design temperatures and reinforcement provided, the locations of critical sections should be designated as Tier 2* information as in DCD Rev. 15. For example, the first two column entries of Table 3H.5-1, Table 3H.5-3 and Table 3H.5-9, and the first three column entries of Table 3H.5-5 and Table 3H.5-7 should be Tier 2*. **(2)** For tables showing steel area/reinforcement required, the maximum steel area/reinforcement required should be designated as Tier 2* information as in DCD Rev. 15, for example, the 7th column entry of Table 3H.5-9 (Sheet 1 of 3). **(3)** Table 3H.5-13, (a) for the 2nd bullet, Tier 2* design information deleted - should be provided, (b) for the 3rd bullet, the added phrase "Design Maximum" is unclear. **(4)** See remark (3) under CI-RAI-SRP3.8.3-SEB1-07.	No	No
CI-RAI-SRP3.8.4-SEB1-04		-	No	Yes	Yes	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	Yes	TBD
CI-RAI-SRP3.8.6-SEB1-01	3.8.6	Yes	No	Yes	No	Yes-TR09	Place holder for TR09-05 & TR09-08	N/A	Yes

CI-RAI-SRP3.8.6-SEB1-02	3.8.6	Yes	Yes	Yes	No	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	N/A	TBD
CI-RAI-TR09-05	3.8.2.4.1	Yes	No	Yes	No	Yes-TR09	DCD R18 markups - Place holder for RAI 3.8.2-SEB1-3	N/A	Yes
CI-RAI-TR09-08	3.8.2.4.1	Yes	No	Yes	No	N/A	DCD Rev. 18 change is in accordance with RAI response: Acceptable.	N/A	Yes
CI-TR85-SEB1-04	3.8.5.1.5.6	Yes	No	Yes	No	N/A	DCD markup for Appendix 3G is in accordance with RAI response: Acceptable.	N/A	Yes
CI-TR85-SEB1-10	3.8.5.1.3/3.8.5.1.6	Yes	No	Yes	YES for: TR09 TR57 TR85 TR03 TR115 SB Report	Yes	**Tier 2*** - Previous plan was for WEC to submit proposed Tier 2* Info from TRs to be placed into DCD and for NRC to review. Per WEC description sent in BG meeting notice for both 3.7 & 3.8: there is no additional information to be designated as Tier 2* in Sections 3.7& 3.8 and Apps. 3G, 3H & 3I. This is not acceptable; however, the staff is identifying what should be Tier 2* in this Table and the companion Tier 2* & Tier 1 Table. TR03 & TR115, related to Section 3.7 Seismic, is addressed separately in the 3.7 Assessment Table. **DCD R18 markups** - A reference to a handbook is missing; **TR revn. update** - Regarding TR-85 R2, the following issues need to be addressed. **(1)** Subsection 2.4.1, Page 16 of 81, 2nd paragraph, 2nd line should read "...2D SASSI horizontal analyses..." and 3rd line should read " Horizontal loads...." **(2)** Section 2.9, 2nd paragraph state: "The	No	No

							governing friction value at the interface zone is a thin soil layer (soil on soil) under the mud mat assumed to have a friction angle of 35 degrees." As indicated in Additional Request (Revision 6) for RAI-TR85-SEB1-10, the sentence should be revised to indicate that the friction value used in the evaluation is based on a governing angle of internal friction of 0.55 for the soil beneath the foundation. See markup proposed in draft response revision 6A for RAI-TR85-SEB1-10.		

Cont.							**(3)** Section 2.9, 4th paragraph. at two locations, "35o" should be revised to "35o." **(4)** Pages 69 and 70 of 81, "0.03" " and "0.045" " are inconsistent with the markups proposed by RAI-TR85-SEB1-10 R6. **(5)** The last sentence on Page 69 of 81 states: "and there is no quality requirement for the backfill material adjacent to the NI (side soil) to maintain stability against sliding." As indicated in Additional Request (Revision 6) for RAI-TR85-SEB1-10, the sentence should be deleted because it is misleading. See markup proposed in draft response revision 6A for RAI-TR85-SEB1-10. **(6)** New text was inserted into Section 1.0, regarding the shear wave velocity criteria for the evaluation in TR-85. The Oct. 2010 road map refers to RAI TR-85-SEB1-2, R04 for this change; however, this text does not appear in that RAI response. The only other RAI related to this topic is TR-85-SEB1-17; however, that criteria only applies to the shear wave velocity criteria related to settlement, not the entire evaluation of TR-85. WEC should explain the intent of the new text.		

CI-TR85-SEB1-17	3.8.5.1.5.5	Yes	No	Yes	No	N/A		N/A	TBD
CI-RAI-TR85-SEB1-27	3.8.5.1.5.	Yes	No	Yes	No	N/A	**(1)** In DCD Rev.18, the phrase "from the equivalent static analyses" in the third bullet of subsection 3.7.2.6 was removed from the proposed markup by the RAI response Rev. 4. **(2)** In several places of DCD Rev. 18 Section 3.8.4.4.1, the descriptions of seismic analysis methods used for design of the auxiliary building and shield building are inconsistent with Table RAI-TR85-SEB1-27-1 on Page 11 of the final response to RAI-TR85-SEB1-27 Rev.4, dated September 23, 2010.	N/A	No
CI-TR85-SEB1-28	3.8.5.1.5.4	Yes	No	No	Yes	N/A	DCD markup for Section 3.8 is in accordance with RAI response: Acceptable.	Yes	Yes
CI-TR85-SEB1-32	3.8.5.1.5.3	Yes	No	Yes	No	Yes-TR85	**TR revn. update** - TR markup is in accordance with RAI response: Acceptable.	N/A	TBD
CI-TR85-SEB1-35	3.8.5.1.3	Yes	No	Yes	No	N/A		N/A	TBD
CI-TR85-SEB1-36	3.8.5.1.5.5	Yes	Yes	Yes	No	N/A		N/A	TBD
CI-TR85-SEB1-37	3.8.5.1.5.5	Yes	Yes	Yes	No	N/A		N/A	TBD
RAI-SRP3.8.2-SEB1-06	3.8.2.1	N/A				N/A			
RAI-SRP3.8.3-SEB1-01	3.8.3.1	N/A				N/A			
RAI-TR09-01	3.8.2.4.1	N/A				N/A			
RAI-TR09-02	3.8.2.4.1	N/A				N/A			

RAI-TR09-03	3.8.2.4.1	N/A				N/A			
RAI-TR09-07	3.8.2.4.1	N/A				N/A			
RAI-TR85-SEB1-05	3.8.5.1.5.2	N/A				N/A			
RAI-TR85-SEB1-12	3.8.5.1.5.7	N/A				N/A			
RAI-TR85-SEB1-14	3.8.5.1.4	N/A				N/A			
RAI-TR85-SEB1-29	3.8.5.1.5.4	N/A				N/A			
RAI-TR85-SEB1-39	3.8.5.1.6	N/A				N/A			
RAI-TR85-SEB1-40	3.8.5.1.5.6	N/A				N/A			

"Table 3"

DCD Section 3.7, Appendix 3G, and Appendix 3I

Comments on Rev. 18 Mark-Up AND Designation of Tier 2* Information DRAFT

(Rev. 18 final checked on 12/07/2010)

Notes:

(1) All tables and figures referenced in the Tier 2* designated material also need to be designated Tier 2*.

(2) ADDITIONAL Tier 2* information is identified below. All information already identified as Tier 2* in the Rev. 18 mark-up remains Tier 2*.

(3) The DCD Rev. 18 Section 3.8.4.4.1mark-up, and the Section 3.7.2.1, 3.7.2.1.1, and 3G.2 mark-ups identified below, need to identify the specific elements of the SB that are analyzed by the equivalent static method.

(4) The review of Rev. 18 mark-ups for 3.7, 3.8, App. 3G, and App. 3H, and applicable final RAI responses, identified instances where the description of the use of equivalent static analysis vs. RSA, CQC/Lindley-Yow vs. Grouping Method/SRP3.7.2 App. A, and SRSS vs. 100-40-40 is unclear or incomplete, and needs clarification. The potentially affected sections are 3.7.2.1; 3.7.2.1.1; 3.7.2.1.3; 3G.2.3; 3G.4.3.1; Table 3G.1-1; Table 3G.1-2; 3H.3; 3H.4; and 3H.5.5.1

(5) The refined ¼ model of the SB roof is NOT described in 3.7 and App. 3G, and is not listed in Table 3G.1-1.

(6) There is a reference in Table 3G.1-2 to a model of the valve room/steel frames/etc. There is no mention nor description of this model in the text of 3.7 and App. 3G, and it is not listed in Table 3G.1-1.

(7) Necessary fixes to the Rev. 18 mark-ups are identified by yellow highlight.

(8) Tier 2* designations are identified just as they would appear in the DCD; i.e., square-bracketed, italicized, with an * at the end.

NOTE: There are additional changes in Rev.18 final, compared to Rev. 18 mark-up. A complete change list is needed, to ensure all changes in Rev.18 final have been reviewed by the staff for acceptability. Previous content comments (yellow highlight) on Rev. 18 mark-up that still apply to Rev. 18 final are flagged by the note [needs to be fixed in Rev.18].

SECTION 3.7

Item 1 - 3.7.1.1 Design Response Spectra

[*The design response spectra are applied at the foundation level in the free field at hard rock sites and at the finished grade in the free field at firm rock and soil sites. The resulting peak horizontal ground acceleration (PGA) values are above 0.1g. This satisfies 10 CFR Part 50, Appendix S, which requires that the horizontal component of the SSE ground motion in the free-field at the foundation elevation (i.e., bottom of foundation) have a peak ground acceleration of at least 0.1g together with an appropriate response spectrum. The definitions (characteristics) of hard rock, firm rock, and soil sites are provided in subsection 3.7.1.4.*]*

Item 2 - 3.7.1.2 Design Time History

[*The acceleration, velocity, and displacement time-history plots for the three orthogonal earthquake components, "H1," "H2," and "V," are presented in Figures 3.7.1-3, 3.7.1-4, and 3.7.1-5. Design horizontal time history, H1, is applied in the north-south (Global X or 1) direction; design horizontal time history, H2, is applied in the east-west (global Y or 2) direction; and design vertical time history is applied in the vertical (global Z or 3) direction.*]*

Item 3 - 3.7.1.3 Critical Damping Values [needs to be fixed in Rev.18]

(Yellow highlight is necessary revision, to be consistent with RAI-SRP3.7.1-SEB1-16 resolution for cable trays. Also, delete Figure 3.7.1-13.)

Energy dissipation within a structural system is represented by equivalent viscous dampers in the mathematical model. The damping coefficients used are based on the material, load conditions, and type of construction used in the structural system. [*The safe shutdown earthquake damping values used in the dynamic analysis of various structures, supports, and equipment are presented in Table 3.7.1-1.*]* The damping values are based on Regulatory Guide 1.61 (Revision 0), ASCE Standard 4-98 (Reference 3), except for the damping value of the primary coolant loop piping, which is based on Reference 22, and conduits, cable trays and their related supports.

The damping values for conduits, cable trays and their related supports are shown in Table 3.7.1-1 ~~and Figure 3.7.1-13~~. The damping value of conduit, empty cable trays, and their related supports is similar to that of a bolted structure, namely 7 percent of critical. The damping value of filled cable trays and supports increases with increased cable fill and level of seismic excitation. Full cable trays use a 10 percent damping value consistent with RG 1.61, Revision 1. ~~For cable trays and supports demonstrated to be similar to those tested, damping values of Figure 3.7.1-13 may be used. These are based on test results (Reference~~

~~19). These tests considered rigid supports, various tray hanger systems, effects of tray types, effects of strut connections, and effects of bracing spacing, unbraced and braced tray systems, and included the use of cable ties. The high damping values observied are provided mainly by the movement, sliding or bouncing of cables within the tray. The AP1000 design for cable tray support configurations are similar to those tested.~~ The limiting condition for design of the AP1000 Standard cable tray supports is for full cable tray weight.
[*For structures or components composed of different material types, the composite modal damping is calculated using the stiffness-weighted method based on Reference 3.*]*

Item 4 - 3.7.1.4 Supporting Media for Seismic Category I Structures [needs to be fixed in Rev.18]

(Yellow highlight is necessary revision.)

The AP1000 nuclear island consists of three seismic Category I structures founded on a common basemat. The three structures that make up the nuclear island are the coupled auxiliary and shield buildings, the steel containment vessel, and the containment internal structures. [*The nuclear island is shown in Figure 3.7.1-14. The foundation embedment depth, foundation size, and total height of the seismic Category I structures are presented in Table 3.7.1-2.*]*

These six profiles are sufficient to envelope sites where the shear wave velocity of the supporting medium at the foundation level exceeds 1000 feet per second (see subsection 2.5.2). [*The design soil profiles include a hard rock site, a soft rock site, a firm rock site, an upper bound soft-to-medium soil site, a soft-to-medium soil site, and a soft soil site. The shear wave velocity profiles and related governing parameters of the six sites considered are as follows:*

- *For the hard rock site, an upper bound case for rock sites using a shear wave velocity of 8000 feet per second.*
- *For the firm rock site, a shear wave velocity of 3500 feet per second to a depth of 120 feet and base rock at the depth of 120 feet.*
- *For the soft rock site, a shear wave velocity of 2400 feet per second at the ground surface, increasing linearly to 3200 feet per second at a depth of 240 feet, and base rock at the depth of 120 feet.*
- *For the upper bound soft-to-medium soil site, a shear wave velocity of 1414 feet per second at ground surface, increasing parabolically to 3394 feet per second at 240 feet, base rock at the depth of 120 feet, and ground water at grade level. The initial soil shear modulus profile is twice that of the soft-to-medium soil site.*
- *For the soft-to-medium soil site, a shear wave velocity of 1000 feet per second at ground surface, increasing parabolically to 2400 feet per second at 240 feet, base rock at the depth of 120 feet, and ground water is assumed at grade level.*
- *For the soft soil site, a shear wave velocity of 1000 feet per second at ground surface, increasing linearly to 1200 feet per second at 240 feet, base rock at the depth of 120 feet, and ground water is assumed at grade level.*

The strain-dependent shear modulus curves for the foundation materials, together with the corresponding damping curves are taken from References 37 and 38 and are shown in

Figures 3.7.1-15 and 3.7.1-16 for rock material and soil material respectively. The different curves for soil in Figure 3.7.1-16 apply to the range of depth within a soil column below grade. The strain-dependent soil material damping is limited to 15 percent of critical damping. The strain- dependent properties used in the SSI analyses for the safe shutdown earthquake are shown in Table 3.7.1-4 and Figure 3.7.1-17 for the firm rock, soft rock, upper bound soft-to-medium soil, soft-to-medium soil, and soft soil properties.

Some variation of soil modeling (water table, soil layering, soil degradation model, etc.) and combinations of these have been demonstrated to have no significant effect on the seismic response of the nuclear island (NI) structures. The governing parameters obtained for the AP600 soil studies are also applicable to the AP1000. Each of the parameters deemed not significant have been analyzed.

For instance, the combination of effects of the different strain dependent soil parameters that effect the strain-iterated shear wave velocity profiles were evaluated and shown not to result in exceedances of the envelope of the generic seismic design in-structure response spectra (ISRS)~~in structure response spectrum~~.]*

<u>Item 5</u> - 3.7.2 Seismic System Analysis

Seismic Category I structures, systems, and components are classified according to Regulatory Guide 1.29. Seismic Category I building structures of AP1000 consist of the containment building (the steel containment vessel and the containment internal structures), the shield building, and the auxiliary building. These structures are founded on a common basemat and are collectively known as the nuclear island or nuclear island structures. [*Key dimensions, such as thickness of the basemat, floor slabs, roofs and walls, of the seismic Category I building structures are shown in Figure 3.7.2-12.*]*

Seismic systems are defined, according to SRP 3.7.2, Section II.3.a, as the seismic Category I structures that are considered in conjunction with their foundation and supporting media to form a soil-structure interaction model. The following subsections describe the seismic analyses performed for the nuclear island. Other seismic Category I structures, systems, equipment, and components not designated as seismic systems (that is, heating, ventilation, and air-conditioning systems; electrical cable trays; piping systems) are designated as seismic subsystems. The analysis of seismic subsystems is presented in subsection 3.7.3.

Seismic Category I building structures are on the nuclear island. Other building structures are classified nonseismic or seismic Category II. Nonseismic structures are analyzed and designed for seismic loads according to the Uniform Building Code (Reference 2) requirements for Zone 2A. [*Seismic Category II building structures are designed for the safe shutdown earthquake using the same methods and design allowables as are used for seismic Category I structures. The acceptance criteria are based on ACI 349 for concrete structures and on AISC N690 for steel structures including the supplemental requirements described in subsections 3.8.4.4.1 and 3.8.4.5. The seismic Category II building structures are constructed to the same requirements as the nonseismic building structures, ACI 318 for concrete structures and AISC-S355 for steel structures.*]*

[*Separate seismic analyses are performed for the nuclear island for each of the six design soil profiles defined in subsection 3.7.1.4. The analyses generate one set of in-structure responses for each of the design soil profiles. The six sets of in-structure responses are enveloped to obtain the seismic design envelope (design member forces, nodal accelerations,* *nodal displacements, and floor response spectra), which are used in the design and analysis of seismic Category I structures, components, and seismic subsystems.*]*

[*Appendix 3G summarizes the types of models and analysis methods that are used in the seismic analyses of the nuclear island, as well as the type of results that are obtained and where they are used in the design. The seismic analyses of the nuclear island are summarized in a seismic analysis summary report. This report describes the development of the finite element models, the soil structure interaction and fixed base analyses, and the results thereof. Seismic response spectra are given in Appendix 3G for the six key locations:*

- *Containment internal structures at reactor vessel support elevation 100.00'.*
- *Containment internal structures at operating deck elevation 134.25'.*
- *Auxiliary shield building north east corner at control room floor elevation 116.50'.*
- *Auxiliary shield building corner of fuel building roof at shield building elevation 179.19'.*
- *Auxiliary shield building roof area elevation 327.41'.*
- *Steel containment vessel near polar crane elevation 224.000'.*]*

<u>Item 6</u> - 3.7.2.1 Seismic Analysis Methods [needs to be fixed in Rev.18]
(Yellow highlight is necessary revision)

Seismic analyses of the nuclear island are performed in conformance with the criteria within SRP 3.7.2 (Revision 2).

[*Equivalent static analyses are not used for the design of the auxiliary building, shield building (except for the tension ring, air inlet, and roof), and containment internal structure. Seismic response spectrum analysis is performed to develop the seismic design loads for these buildings, and the loads generated include the amplified load due to flexibility and the distribution of this load to the surrounding structures.*]*

<u>Item 7</u> - 3.7.2.1.1 Equivalent Static Acceleration Analysis [needs to be fixed in Rev.18]
(Yellow highlight is necessary revision)

[*Equivalent static analyses, using computer program ANSYS (Reference 36), are performed to obtain the seismic forces and moments required only for the structural design of the shield building tension ring, air inlet, and roof; the steel containment vessel; and the nuclear island basemat ~~(see subsection 3.8.2.4.1.1)~~. Equivalent static loads are applied to the finite element models using the maximum acceleration results from the time history analyses for the six design soil profiles. Accidental torsional moments are applied as described in subsection 3.7.2-11.*]*

<u>Item 8</u> - 3.7.2.1.2 Time-History Analysis and Complex Frequency Response Analysis [needs to be fixed in Rev.18]

(Revision needed. The NI05 model also needs to be discussed here wrt its use for time history analysis of flexible regions, with a reference to an appropriate 3G subsection, similar to the NI10 and NI20 models. The discussion needs to be Tier 2*. Note that the discussion in TR-03 covering this topic has been identified for clarification. TR-03, DCD 3.7, and DCD App. 3G need to be consistent on this topic.)

[*Mode superposition time-history analyses using computer program ANSYS and complex frequency response analysis using computer program SASSI are performed to obtain the in-structure seismic response needed in the analysis and design of seismic subsystems. Three dimensional finite element shell models of the nuclear island structures are used in conjunction with the design soil profiles presented in subsection 3.7.1.4 to obtain the in-*

structure responses. Stick models are coupled to the shell models of the concrete structures for the containment vessel, polar crane, reactor coolant loop, pressurizer, and core makeup tanks. Two models are used. The fine (NI10) model, as described in subsection 3G.2.2.1, is used to define the seismic response for the hard rock site. The coarse (NI20) model, as described in subsection 3G.2.2.2, is used for the soil structure interaction (SSI) analyses and is set up in both ANSYS and SASSI.]* The models and analyses are described in Appendix 3G.

[*For the hard rock site, the soil-structure interaction effect is negligible. Therefore, for the hard rock site, the nuclear island is analyzed as a fixed-base structure, using computer program ANSYS without the foundation media. The three components of earthquake (two horizontal and one vertical time histories) are applied simultaneously in the analysis. Since the NI10 finite element model of the auxiliary and shield building uses shell elements to represent the 6-foot-thick basemat, the nodes of the basemat element are at the center of the basemat (elevation 63'-6"). The finite element model of the containment internal structures uses solid elements, which extend down to elevation 60'-6". When the finite element models are combined and used in the time history analyses, the auxiliary building finite element model is fixed at the shell element basemat nodes (elevation 63'-6") and the base of the containment internal structures is fixed at the bottom of the solid element base nodes (elevation 60'-6"). This difference in elevation of the base fixity is not significant since the concrete between elevations 60'-6" and 63'-6", below the auxiliary building, is nearly rigid. There is no lateral support due to soil or hard rock below grade. This case results in higher response than a case analyzed with full lateral support below grade.*]*

Item 9 - 3.7.2.1.3 Response Spectrum Analysis [needs to be fixed in Rev.18]
(Yellow highlight is necessary revision. Also, the NI05 model needs to be discussed here wrt its use for RSA, with a reference to an appropriate 3G subsection, similar to the NI10 and NI20 models. The discussion needs to be Tier 2*. Ensure consistency between TR-03, DCD 3.7 and DCD App. 3G.)

Response spectral analysis is used for the evaluation of the nuclear island structures.
[*Response spectrum analyses are used to perform an analysis of a particular structure or portion of structure using the procedures described in 3G.4.3.1*~~subsections 3.7.2.6, 3.7.2.7, and 3.7.3~~.]*

Item 10 - 3.7.2.3 Procedure Used for Modeling

Based on the general plant arrangement, three-dimensional, finite element models are developed for the nuclear island structures: a finite element model of the coupled shield and auxiliary buildings, a finite element model of the containment internal structures, a finite element model of the shield building roof, and an axisymmetric shell model of the steel containment vessel. These three-dimensional, finite element models provide the basis for the development of the dynamic model of the nuclear island structures.

[*The finite element models of the coupled shield and auxiliary buildings, and the containment internal structures are based on the gross concrete section with the modulus based on the specified compressive strength of concrete reduced by a factor of 0.8 to consider the effect of cracking as recommended in Table 6-5 of FEMA 356 (Reference 5).*]* This 80 percent value is supported by non-linear ABAQUS analyses performed on the Nuclear Island finite element model. The comparison between linear and non-linear models show that the 80% stiffness model response spectra enveloped the non-linear model, providing a conservative approach in terms of response spectra and maximum stresses obtained in the SB wall.

Seismic subsystems coupled to the overall dynamic model of the nuclear island include the coupling of the reactor coolant loop model to the model of the containment internal structures, and the coupling of the polar crane model to the model of the steel containment vessel. [*The criteria used for decoupling seismic subsystems from the nuclear island model are according to Section II.3.b of SRP 3.7.2, Revision 2. The total mass of other major subsystems and equipment is less than one percent of the respective supporting nuclear island structures; therefore, the mass of other major subsystems and equipment is included as concentrated lumped-mass only.*]*

[*The seismic analysis of the water inside the PCCWST was performed for the AP600. It was concluded that the low-frequency sloshing mode is not significant to the response of the NI away from the SB roof and that this conclusion could be extended to the AP1000 design. Further analysis indicated that the sloshing mass ratio remained essentially unchanged between AP600 and AP1000.*]*

Item 11 - 3.7.2.3.1 Coupled Shield & Auxiliary Building and Containment Internal Structures

The finite element models of the coupled shield and auxiliary buildings and the reinforced concrete portions of the containment internal structures are based on the gross concrete section with the modulus based on the specified compressive strength of concrete of contributing structural walls and slabs. The properties of the concrete-filled structural modules are computed using the combined gross concrete section and the transformed steel face plates of the structural modules. The modulus is reduced by a factor of 0.8 to consider the effect of cracking. [*Furthermore, the weight density of concrete plus the uniformly distributed miscellaneous dead weights are considered by adding surface mass or by adjusting the material mass density of the structural elements. An equivalent tributary slab area load of 50 pounds per square foot is considered to represent miscellaneous deadweight such as minor equipment, piping and raceways. 25 percent of the floor live load or 75 percent of the roof snow load, whichever is applicable, is considered as mass in the global seismic models.*]*

[*Major equipment weights are distributed over the floor area or are included as concentrated lumped masses at the equipment locations. The major equipment supported by the CIS is represented by stick models connected to the CIS, and include reactor coolant loop, the pressurizer, and the core makeup tank. The core makeup tank model is used only in the nuclear island fine (NI10) model; the core makeup tank is represented by mass in the nuclear island coarse model (NI20).*]* The finite element models of the coupled shield and auxiliary buildings and the containment internal structures are described in Appendix 3G. The auxiliary and shield building is modeled with shell elements and the base of the finite element model is at the middle of the basemat at elevation 63′-6″. The bottom of the containment and internal structures are modeled with solid elements and the base of the finite element model is at the underside of the basemat at elevation 60′-6″. The interface between the models is at a radius of 71′-0″ at the mid-surface of the shield building.

Item 12 - 3.7.2.3.2 Steel Containment Vessel

[This method used to construct a stick model from the axisymmetric shell model of the containment vessel is verified by comparison of the natural frequencies determined from the stick model and the shell of revolution model as shown in Table 3G.2-2.The shell of revolution vertical model (n = 0 harmonic) has a series of local shell modes of the top head above elevation 265' between 23 and 30 hertz. These modes are predominantly in a direction normal to the shell surface and cannot be represented by a stick model. These local modes have small contribution to the total response to a vertical earthquake as they are at a high frequency where seismic excitation is small. The only seismic Category I components attached to this portion of the top head are the water distribution weirs of the passive containment cooling system. These weirs are designed such that their fundamental frequencies are outside the 23 to 30 hertz range of the local shell modes.]*

[*The containment air baffle, presented in subsection 3.8.4.1.3, is supported from the steel containment vessel at regular intervals so that a gap is maintained for airflow. It is constructed with individual panels which do not contribute to the stiffness of the containment vessel. The fundamental frequency of the baffle panels and supports is about twice the fundamental frequency of the containment vessel. The mass of the air baffle is small, equal to approximately 10 percent of the vessel plates to which it is attached. The air baffle, therefore, is assumed to have negligible interaction with the steel containment vessel. Only the mass of the air baffle is considered and added at the appropriate elevations of the steel containment vessel stick model.*]*

Item 13 - 3.7.2.5 Development of Floor Response Spectra

[*The design floor response spectra are generated according to Regulatory Guide 1.122.*]*

[*The spectral peaks are broadened by ±15 percent to account for the variation in the structural frequencies, due to the uncertainties in parameters such as material and mass properties of the structure and soil, damping values, seismic analysis technique, and the seismic modeling technique. Figure 3.7.2-14 shows the broadening procedure used to generate the design floor response spectra. Spectral peaks at frequencies associated with fundamental soil structure interaction frequencies are reviewed. If there is a "valley" between peaks due to different soil profiles and not the building modal response, then this valley is filled by extending the broadening of the lower peak horizontally until it meets the broadened upper peak.*]*

Item 14 - 3.7.2.6 Three Components of Earthquake Motion [needs to be fixed in Rev.18] (Revision needed. The combination methods described for equivalent static analysis using the axisymmetric containment vessel model are NOT consistent with 3 directions of earthquake motion, NOT consistent with the Rev. 18 mark-up of Table 3G.1-2, and NOT consistent with DCD Table 3.8.2-5, which lists 2 horizontal static acceleration profiles - one for the N-S direction and one for the E-W direction. Three components of response need to be combined by a rule - either SRSS or the 24 combinations of 100-40-40. Revise the highlighted text accordingly.)

[*Seismic system analyses are performed considering the simultaneous occurrences of the two horizontal and the vertical components of earthquake.*

In mode superposition time-history analyses using computer program ANSYS, the three components of earthquake are applied either simultaneously or separately. In the ANSYS

analyses with the three earthquake components applied simultaneously, the effect of the three components of earthquake motion is included within the analytical procedure so that further combination is not necessary.
In analyses with the earthquake components applied separately and in the response spectrum and equivalent static analyses, the effect of the three components of earthquake motion are combined using one of the following methods:
• For seismic analyses with the statistically independent earthquake components applied separately, the time-history responses from the three earthquake components are combined algebraically at each time step to obtain the combined response time-history. This method is used in the SASSI analyses.
• The peak responses due to the three earthquake components from the response spectrum and equivalent static analyses are combined using the square root of the sum of squares (SRSS) method.
• The peak responses due to the three earthquake components are combined directly, using the assumption that when the peak response from one component occurs, the responses from the other two components are 40 percent of the peak (100 percent-40 percent-40 percent method). Combinations of seismic responses from the three earthquake components, together with variations in sign (plus or minus), are considered. This method is used in the nuclear island basemat analyses, the containment vessel analyses and the shield building roof analyses.
The containment vessel is analyzed using axisymmetric finite element models. These axisymmetric building structures are analyzed for one horizontal seismic input from any horizontal direction and one vertical earthquake component. Responses are combined by either the square root of the sum of squares method or by a modified 100 percent-40 percent-40 percent method in which one component is taken at 100 percent of its maximum value and the other is taken at 40 percent of its maximum value.]*

Item 15 - 3.7.2.7 Combination of Modal Responses [needs to be fixed in Rev.18] (Yellow highlight is necessary revision)

The modal responses of the response spectrum system structural analysis are combined using the procedures described in 3G.4.3. ~~grouping method shown in Section C of Regulatory Guide 1.92, Revision 1. When high frequency effects are significant, they are included using the procedure given in AppendixA to SRP 3.7.2.~~ In the fixed base mode superposition time history analysis of the hard rock site, the total seismic response is obtained by superposing the modal responses within the analytical procedure so that further combination is not necessary.

Item 16 - 3.7.2.8 Interaction of Seismic Category II and Nonseismic Structures with Seismic Category I Structures, Systems, or Components

[*Nonseismic structures are evaluated to determine that their seismic response does not preclude the safety functions of seismic Category I structures, systems or components. This is accomplished by satisfying one of the following:*

- *The collapse of the nonseismic structure will not cause the nonseismic structure to strike a seismic Category I structure, system or component.*

- *The collapse of the nonseismic structure will not impair the integrity of seismic Category I structures, systems or components.*
- *The structure is classified as seismic Category II and is analyzed and designed to prevent its collapse under the safe shutdown earthquake.*

The structures adjacent to the nuclear island are the annex building, the radwaste building, and the turbine building.]*

Item 17 - 3.7.2.8.1 Annex Building

[*The portion of the annex building adjacent to the nuclear island is classified as seismic Category II. The structural configuration is shown in Figure 3.7.2-19. The annex building is analyzed for the safe shutdown earthquake for the six soil profiles described in subsection 3.7.1.4. For the hard rock site, a range of soil properties is assumed for the layer above rock at the level of the nuclear island foundation. Seismic input is defined by response spectra applied at the base of a dynamic model of the annex building. The seismic response spectra input at the base of the annex building are the envelopes of the range of soil sites and also envelope the AP1000 design free field ground spectra shown in Figures 3.7.1-1 and 3.7-1-2. The envelope of the maximum building response acceleration values is applied as equivalent static loads to a more detailed static model. See subsection 3.7.2.8.4 for more discussion of modeling and seismic analysis.*

The minimum space required between the annex building and the nuclear island to avoid contact is obtained by absolute summation of the deflections of each structure obtained from either a time history or a response spectrum analysis for each structure. The maximum displacement of the roof of the annex building is 1.6 inches in the east-west direction. The minimum clearance between the structural elements of the annex building above grade and the nuclear island is 4 inches.]*

Item 18 - 3.7.2.8.2 Radwaste Building

[*The radwaste building is classified as nonseismic and is designed to the seismic requirements of the Uniform Building Code, Zone 2A with an Importance Factor of 1.25. As shown in the radwaste building general arrangement in Figure 1.2-22, it is a small steel framed building. If it were to impact the nuclear island or collapse in the safe shutdown earthquake, it would not impair the integrity of the reinforced concrete nuclear island. The minimum clearance between the structural elements of the radwaste building above grade and the nuclear island is 4 inches.*

Three methods are used to demonstrate that a potential radwaste building impact on the nuclear island during a seismic event will not impair its structural integrity:

- *The maximum kinetic energy of the impact during a seismic event considers the maximum radwaste building and nuclear island velocities. The total kinetic energy is considered to be absorbed by the nuclear island and converted to strain energy. The* *deflection of the nuclear island is less than 0.2". The shear forces in the nuclear island walls are less than the ultimate shear strength based on a minus one standard deviation of test data.*

- *Stress wave evaluation shows that the stress wave resulting from the impact of the radwaste building on the nuclear island has a maximum compressive stress less than the concrete compressive strength.*

- *An energy comparison shows that the kinetic energy of the radwaste building is less than the kinetic energy of tornado missiles for which the exterior walls of the nuclear island are designed.*]*

Item 19 - 3.7.2.8.3 Turbine Building

[*The south end of the turbine building is separated from the rest of the turbine building by a 2'-0" thick reinforced concrete wall that provides a robust structure around the first bay. This wall isolates the first bay of the turbine building from the general area of the turbine building and from the adjacent yard area. The main segment of this wall is located on column line 11.2. This wall extends from El.100'-0" basemat to the El.161'-0" operating floor. The first bay of the turbine building is classified as seismic Category II. The other bays are classified as non-seismic.*

The first bay of the turbine building is analyzed for the safe shutdown earthquake for the six soil profiles described in subsection 3.7.1.4. For the hard rock site, a range of soil properties is assumed for the layer above rock at the level of the nuclear island foundation. Seismic input is defined by response spectra applied at the base of a dynamic model of the first bay of the turbine building. The seismic response spectra input at the base of the first bay of the turbine building are the envelopes of the range of soil sites and also envelope the AP1000 design free field ground spectra shown in Figures 3.7.1-1 and 3.7-1-2. See subsection 3.7.2.8.4 for more discussion of modeling and seismic analysis.

The first bay is designed in accordance with ACI-349 for concrete features and AISC-N690 for steel features.

For the non-seismic portion of the Turbine Building, seismic design is upgraded from Zone 2A, Importance Factor of 1.25, to Zone 3 with an Importance Factor of 1.0 in order to provide margin against collapse during the safe shutdown earthquake. The turbine building is an eccentrically braced steel frame structure designed to meet the following criteria:

The turbine building is designed in accordance with ACI-318 for concrete structures and with AISC for steel structures. Seismic loads are defined in accordance with the 1997 Uniform Building Code provisions for Zone 3 with an Importance Factor of 1.0. For an eccentrically braced structure the resistance modification factor is 7 (UBC-97, reference 1) using strength design. When using allowable stress design, the allowable stresses are not *increased by one third for seismic loads, and the resistance modification factor is increased to 10 (UBC-91).*

The design of the lateral bracing system complies with the seismic requirements for eccentrically braced frames given in section 9.3 of the AISC Seismic Provisions for Structural Steel Buildings (reference 34). Quality assurance is in accordance with ASCE 7-98 (reference 35) for the lateral bracing system.]*

Item 20 - 3.7.2.8.4 Seismic Modeling and Analysis of Seismic Category II Building Structures

[*Seismic Category II structures, systems, and components are designed so that the safe shutdown earthquake does not cause unacceptable structural failure or interaction with seismic Category I items. Therefore, the seismic response of seismic Category II buildings must be obtained so that they can be designed to meet the seismic Category II requirements as given in DCD subsection 3.2.1.1.2. Seismic Category II structures are analyzed and evaluated in the same manner as seismic Category I structures. The foundation of the nonseismic portion is modeled with the associated mass distributed on it so that the soil structure interaction during a seismic event is reflected in the analysis.*

The seismic analyses performed for the adjacent seismic Category II structures are simulated 3D analyses. The seismic analyses are performed primarily using 2D SASSI models. To properly account for 3D effect, the response from 2D and 3D SASSI analyses of the seismic Category II buildings on rigid foundations are compared and a 3D effects factor is developed from this comparison. Three soil cases (upper bound soft to medium [UBSM], soft to medium [SM], and soft soil [SS]) are used to determine the 3D factor. Shown in Figures 3.7.2-20 and 3.7.2-21 are the 2D SASSI models with adjacent building structures. The seismic Category II buildings are modeled as stick models. The 3D model with adjacent structures is shown in Figure 3.7.2-22.

Seismic Category II buildings are designed using envelope foundation response spectra (FRS). The development of these FRS shall be based on a number of analyses results from the SASSI analyses. The seismic Category II FRS, at the base of the seismic Category II structures, shall be the envelope of the SASSI seismic Category II foundation response spectra resulting from the following seismic inputs/soil profiles:

AP1000 CSDRS – HR at El. 60.5'.
AP1000 CSDRS – FR, SR, UBSM, SM, and SS soil profiles with AP1000 CSDRS spectra input at plant grade.

GMRS deep soil site – Deep soil site profiles (LB, BE, and UB) with deep soil site GMRS at plant grade.

AP1000 hard rock high frequency (HRHF) – For rock sites, HRHF at plant grade (HRHF-PG) shall be developed using AP1000 HRHF spectra at El. 60.5' and a range of backfill soil profiles in accordance with these procedures and Regulatory Guide 1.208, Appendix E. The backfill soil under the annex and turbine buildings uses a parabolic soil profile as a function of depth (El. 100' to El. 60.5') and uses EPRI (1993) strain dependent curves. The HRHF-PG spectra are generated using soil profiles corresponding to a shear wave velocity of 500 fps, 750 fps, and 1000 fps at El. 100'.

For each soil case, 2D SASSI analyses are performed and the results at three locations at the base of the seismic Category II structures are enveloped. The 3D effect factor is applied to the envelope foundation spectra and used for the design of the annex building and turbine building first bay.

Response spectrum analyses (using detailed finite element building models) shall be used to obtain seismic design loads for the seismic Category II building design. The seismic input to the response spectrum analyses is the envelope foundation seismic response spectra obtained from the SASSI analyses.

The maximum bearing demand and maximum relative displacement shall be established from the 2D SASSI analyses.

The COL applicant performs the following screening criteria to determine if the applicant has to perform further analysis for its site. If the requirements given below are not met, then the site applicant can perform site-specific analyses to demonstrate that its site-specific seismic Category II foundation seismic response spectra are less than the AP1000 annex building and turbine building first bay generic design envelope foundation spectra.

1.The site meets subsection 2.5.4.5 DCD soil uniformity requirements.

2. For soil sites, the site GMRS is enveloped by the AP1000 CSDRS with soil profiles SS, SM, UBSM, SR, FR, and HR.

3. For HRHF sites, the site GMRS is enveloped by the AP1000 HRHF response spectra with a minimum backfill surface shear wave velocity of 500 fps, and a minimum lateral extent of the backfill corresponding to a line extending down from the surface at a one horizontal to one vertical (1H:1V) slope from the outside footprint limit of the seismic Category II structure.

4. The bearing capacity with appropriate factor of safety is greater than or equal to the bearing demand.]*

<u>Item 21</u> - 3.7.2.10 Use of Constant Vertical Static Factors

[*The vertical component of the safe shutdown earthquake is considered to occur* *simultaneously with the two horizontal components in the seismic analyses. Therefore, constant vertical static factors are not used for the design of seismic Category I structures.*]*

Item 22 - 3.7.2.11 Method Used to Account for Torsional Effects [needs to be fixed in Rev.18]

Special Note: Information in this section is not applicable to 3-D models. This is a carryover from Rev. 15, when stick models were used. This section needs to be completely re-written to describe approach used for the 3-D models. Delete the following and provide new write-up**. The new write-up needs to be designated as Tier 2*.**

"The seismic analysis models of the nuclear island incorporate the mass and stiffness eccentricities of the seismic Category I structures and the torsional degrees of freedom. An accidental torsional moment is included in the design of the nuclear island structures. The accidental torsional moment due to the eccentricity of each mass is determined using the following:

- Horizontal mass properties of the building at each elevation.
- The maximum absolute value of the north-south and east-west nodal accelerations.
- An assumed accidental eccentricity equal to ±5 percent of the maximum building dimensions at the elevation of the mass.
- The torsional moments due to eccentricities of the masses at each elevation are assumed to act in the same direction on each structure.
- The torsional moments are applied in two load cases:
  – TOR-NS Case, TNS – accidental torsional moment caused by a Y-eccentricity of the mass during a shock in the X direction
  – TOR-EW Case, TEW – accidental torsional moment caused by a X-eccentricity of the mass during a shock in the Y direction
- The results of each of these torsional load cases are combined absolutely with the results of the corresponding translation acceleration case. The three directions are then combined as described in subsection 3.7.2.6, i.e. (ETC.)"

Item 23 - 3.7.3.16 Analysis of Seismic Category I Tanks

[*This subsection describes the seismic analyses for the large, atmospheric seismic Category I pools and tanks. These are reinforced concrete structures with stainless steel liners or with structural modules, as discussed in subsections 3.8.3 and 3.8.4. They include the spent fuel pit in the auxiliary building, the in-containment refueling water storage tank, and the passive containment cooling water tank incorporated into the shield building roof. There are no other seismic Category I tanks.*

The seismic analyses of the tank consider the impulsive and convective forces of the water as well as the flexibility of the walls. For the spent fuel pit, cask loading pit, cask washdown pit and fuel transfer canal, the impulsive loads are calculated by considering a portion of the water mass responding with the concrete walls. The impulsive forces are calculated by *conventional methods for rigid tanks. The passive containment cooling water tank is analyzed using methods described in Reference 15 for toroidal tanks. It is also analyzed by finite element methods. The in-containment refueling water storage tank is irregular in plan and is analyzed by finite element methods.*]*

Item 24 - 3.7.5 Combined License Information

[*3.7.5.1 Seismic Analysis of Dams*
Combined License applicants referencing the AP1000 certified design will evaluate dams whose failure could affect the site interface flood level specified in subsection 2.4.1.2. The evaluation of the safety of existing and new dams will use the site-specific safe shutdown earthquake.

3.7.5.2 Post-Earthquake Procedures
Combined License applicants referencing the AP1000 certified design will prepare site-specific procedures for activities following an earthquake. These procedures will be used to accurately determine both the response spectrum and the cumulative absolute velocity of the recorded earthquake ground motion from the seismic instrumentation system. The procedures and the data from the seismic instrumentation system will provide sufficient information to guide the operator on a timely basis to determine if the level of earthquake ground motion requiring shutdown has been exceeded. An activity of the procedures will be to address measurement of the post-seismic event gaps between the new fuel rack and the walls of the new fuel storage pit and between the individual spent fuel racks and from the spent fuel racks to the spent fuel pool walls and to take appropriate corrective action if needed (such as repositioning the racks or analysis of the as-found condition). The procedures will follow the guidance of EPRI Reports NP-5930 (Reference 1), TR-100082 (Reference 17), and NP-6695 (Reference 18), as modified by the NRC staff (Reference 32).

3.7.5.3 Seismic Interaction Review
The seismic interaction review will be updated by the Combined License holder for as-built information. This review is performed in parallel with the seismic margin evaluation. The review is based on as-procured data, as well as the as-constructed condition. The as-built seismic interaction review is not provided with the COL application, but is completed prior to fuel load.

3.7.5.4 Reconciliation of Seismic Analyses of Nuclear Island Structures
The Combined License holder will reconcile the seismic analyses described in subsection 3.7.2 for detail design changes, such as those due to as-procured or as-built changes in component mass, center of gravity, and support configuration based on as-procured equipment information. Deviations are acceptable based on an evaluation consistent with the methods and procedure of Section 3.7 provided the amplitude of the seismic floor response spectra, including the effect due to these deviations, does not exceed the design basis floor response spectra by more than 10 percent. The Combined License holder will complete this reconciliation prior to fuel load.]*

<u>APPENDIX 3G</u>

<u>Item 25</u> - 3G.1 Introduction

[*References 3 and 6 provide a summary of dynamic and seismic analysis results (i.e., modal model properties, accelerations, displacements, response spectra) and the nuclear island liftoff analyses. The seismic analyses of the nuclear island are summarized in a seismic analysis summary report. Deviations from the design due to as-procured or as-built conditions are acceptable based on an evaluation consistent with the methods and procedures of Sections 3.7 and 3.8 provided the following acceptance criteria are met:*

- *The structural design meets the acceptance criteria specified in Section 3.8.*
- *The seismic floor response spectra (FRS) meet the acceptance criteria specified in subsection 3.7.5.4*.

Depending on the extent of the deviations, the evaluation may range from documentation of an engineering judgment to performance of a revised analysis and design. The results of the evaluation will be documented in an as-built summary report by the Combined License applicant.

Table 3G.1-1 and Figure 3G.1-1 summarize the types of models and analysis methods that are used in the seismic analyses of the nuclear island, as well as the type of results that are obtained and where they are used in the design. Table 3G.1-2 summarizes the dynamic analyses performed and the methods used for combination of modal responses and directional input.]*

<u>Item 26</u> - 3G.2 Nuclear Island Finite Element Models [needs to be fixed in Rev.18] (Yellow highlight is necessary revision)

Equivalent static analyses are not used for the design of the auxiliary building, shield building (except for the tension ring, air inlet, and roof), and containment internal structure. Seismic response spectrum analysis is performed to develop the seismic design loads for these buildings, and the loads generated include the amplified load due to flexibility and the distribution of this load to the surrounding structures.

<u>Item 27</u> - 3G.2.1.1 Coupled Auxiliary and Shield Building

The finite element shell dynamic model of the coupled ASB is a finite element model using primarily shell elements. The portion of the model up to the elevation of the auxiliary building roof is developed using the solid model features of ANSYS, which allow definition of the geometry and structural properties. The nominal element size in the auxiliary building model is about 9 feet so that each wall has two elements for the wall height of about 18 feet between floors. This mesh size, which is the same as that of the solid model, has sufficient refinement for global seismic behavior. It is combined with a finite element model of the shield building roof and cylinder above the elevation of the auxiliary building roof. [*This model is shown in Figure 3G.2-1. This finite element shell dynamic model is part of the NI10 model.*]*

[*Since the water in the passive containment cooling system tank responds at a very low frequency (sloshing) and does not affect building response, the passive containment cooling system tank water mass is reduced to exclude the low frequency water sloshing mass.*]* The wall thickness of the bottom portion of the shield building (elevation 63.5′ to 81.5′) is modeled as one half (1.5′) since the CIS model is connected to this portion and extends out to the mid-radius of the shield building cylindrical wall. Local portions of the ASB floors and walls are modeled with sufficient detail to give the response of the flexible areas.

<u>Item 28</u> - 3G.2.1.2 Containment Internal Structures

The finite element shell model of the containment internal structures is a finite element model using primarily shell elements for the walls and floors and solid elements for the mass concrete. It is developed using the solid model features of ANSYS, which allow definition of the geometry and structural properties. This model is used in both static and dynamic analyses. It models the inner and outer mass concrete basemats embedding the lower portion of the containment vessel, and the concrete structures above the mass concrete inside the containment vessel. [*The walls and basemat inside containment for this model are shown in Figure 3G.2-2. The basemat (dish) outside the containment vessel is shown in Figure 3G.2-3.*]* This finite element shell dynamic model is part of the NI10 model. Static analyses are also performed on the model to obtain member forces in the walls. This model is also used in the 3D finite element basemat model (see subsection 3.8.5.4.1).

<u>Item 29</u> - 3G.2.1.3 Containment Vessel

The SCV is a freestanding, cylindrical, steel shell structure with ellipsoidal upper and lower steel domes. The finite element model of the containment vessel is an axisymmetric model fixed at elevation 100′. Static analyses are performed with this model to obtain shell stresses as described in subsection 3.8.2.4.1.1. The model is also used to develop modal properties (frequencies and mode shapes).[*The three-dimensional, lumped-mass stick model of the SCV is developed based on the axisymmetric shell model. Figure 3G.2-4 presents the SCV stick model. In the stick model, the properties are calculated as follows:*

• Members representing the cylindrical portion are based on the properties of the actual circular cross section of the containment vessel.

• Members representing the bottom head are based on equivalent stiffnesses calculated from the shell of revolution analyses for static 1.0g in vertical and horizontal directions.

• Shear, bending and torsional properties for members representing the top head are based on the average of the properties at the successive nodes, using the actual circular cross section. These are the properties that affect the horizontal modes. Axial properties, which affect the vertical modes, are based on equivalent stiffnesses calculated from the shell of revolution analyses for static 1.0g in the vertical direction.

The equivalent static acceleration analyses of the containment vessel use a finite element shell model with a refined mesh in the area adjacent to the large penetrations. Comparison of this with a time history analysis for the regions immediately surrounding the large penetrations verifies that the loads from equivalent static analysis are conservative to time history using a representative study.

The stick model is combined with the polar crane stick model as shown in Figure 3G.2-4. Modal properties of the containment vessel with and without the polar crane are shown in Table 3G.2-1. It is connected to nodes on the dish model. NI10 node numbers are shown in red and NI20 node numbers are shown in black.

The method used to construct a stick model from the axisymmetric shell model of the containment vessel is verified by comparison of the natural frequencies determined from the stick model and the shell of revolution model as shown in Table 3G.2-2]* The shell of revolution vertical model (n = 0 harmonic) has a series of local shell modes of the top head above elevation 265′ between 23 and 30 hertz. These modes are predominantly in a direction normal to the shell surface and cannot be represented by a stick model. These local modes have small contribution to the total response to a vertical earthquake as they are at a high frequency where seismic excitation is small. The only seismic Category I components attached to this portion of the top head are the water distribution weirs of the passive containment cooling system. These weirs are designed such that their fundamental frequencies are outside the 23 to 30 hertz range of the local shell modes.

[*An evaluation was made of the connection of the bottom of the steel containment vessel stick model to the CIS finite element model. Comparisons were made between the unconstrained fully symmetric, radially constrained fully symmetric, and original asymmetric connectivity models. The response spectra at the elevation of the polar crane girder for the first two models are almost identical, and the third model only had minor differences. Based on this comparison, the unconstrained fully symmetric connectivity model is used.*]*

Item 30 - 3G.2.1.4 Polar Crane

The polar crane is supported on a ring girder, which is an integral part of the SCV at elevation 228′-0″, as shown in Figure 3.8.2-1. [*It is modeled as a multi-degree of freedom system attached to the steel containment shell at elevation 224' (midpoint of ring girder) as shown in Figure 3G.2-4. The polar crane is modeled using a simplified and detailed model. The simplified model has five masses at the mid-height of the bridge at elevation 233'-6" and one mass for the trolley, as shown in Figure 3G.2-5A. The polar crane model includes the flexibility of the crane bridge girders and truck assembly, and the containment shell's local flexibility. When fixed at the center of containment, the model shows fundamental frequencies of 3.3 hertz transverse to the bridge, 7.0 hertz vertically, and 6.4 hertz along the bridge. The Detailed Model of the polar crane consists of 28 nodes is defined having 96 dynamic degrees of freedom. It is used to verify the accuracy of the simplified model. This model is shown in Figure 3G.2-5B.*]*

Nodes 1 to 4 represent the Trucks with elevation at top of rails (TOR). There are four nodes that are coincident with nodes 1 to 4 and used to add the local SCV stiffnesses (nodes 465 to 468, not shown in Figure).

1. Nodes 9 to 12 represent the trolley. The trolley is connected to the centerline of the polar crane girders at nodes 9 and 10.
2. Nodes 13 to 26 are located on the polar crane girders. The end nodes (13, 19, 20 and 26) are used to connect the cross beams to the girders; these nodes are also attached to the trucks (nodes 1 to 4) by rigid links.
3. Node 470 is at the center of containment at the top of rail elevation. Nodes 465 to 468 are attached to node 470 using rigid links.
4. Node 29, not shown in Figure, is located on the SCV. It is attached to 470 by a rigid link.

Item 31 - 3G.2.1.5 Major Equipment and Structures Using Stick Models

[*The major equipment supported by the CIS is represented by stick models connected to the CIS. These stick models are the reactor coolant loop model shown in Figure 3G.2-6, the pressurizer model shown in Figure 3G.2-7, and the core makeup tank model shown in Figure 3G.2-8.*]* The core makeup tank model is used only in the nuclear island fine (NI10) model; the core makeup tank is represented by mass in the nuclear island coarse model (NI20).

Item 32 - 3G.2.2 Nuclear Island Dynamic Models [needs to be fixed in Rev.18]

(Note: The NI05 model needs to be described in this section of App. 3G. It is used for RSA and for time history seismic analysis. A clear description of its use and how it fits in to the overall analysis methodology is needed.)

Finite element shell models (3D) of the nuclear island concrete structures are used for the time history seismic analyses. Stick models are coupled to the shell models of the concrete structures for the containment vessel, polar crane, the reactor coolant loop and pressurizer. Two models are used. The fine (NI10) model is used to define the seismic response for the hard rock site. The coarse (NI20) model is used for the soil structure interaction (SSI) analyses. It is similar to the NI10 model with the exception that the mesh size for the ASB and CIS is approximately 20 feet instead of 10 feet. This model is set up in both ANSYS and SASSI. The NI10 and NI20 models are described in the subsections below.

<u>Item 33</u> - 3G.2.2.1 NI10 Model

[*The large solid-shell finite element model of the AP1000 nuclear island shown in Figure 3G.2-9 combines the ASB solid-shell model described in subsection 3G.2.1.1, and the CIS solid-shell model described in subsection 3G.2.1.2*.]* The containment vessel and major equipment that are supported by the CIS are represented by stick models and are connected to the CIS. These stick models are the SCV and the polar crane models, the reactor coolant loop model, core makeup tank models, and the pressurizer model. The stick models are described in subsections 3G.2.1.3 and 3G.2.1.4. [*The CIS and attached sticks are shown in Figure 3G.2-10. This AP1000 nuclear island model is referred to as the NI10 or fine model. The ASB portion of this model has a mesh size of approximately 10 feet*.]*

[*The SCV is connected to the CIS model using constraint equations. The SCV at the bottom of the stick at elevation 100' (node 130401) is connected to CIS nodes at the same elevation. Figure 3G.2-4 shows the SCV stick model with the constraint equation nodes. The nodes are defined using a cylindrical coordinate system whose origin coincides with the center of containment (node 130401). The CIS vertical displacement is tied rigidly (constrained) to the vertical displacement and RX and RY rotations of node 130401. The CIS tangential displacement is tied rigidly (constrained) to the horizontal displacement and RZ rotation of node 130401*.]*

<u>Item 34</u> - 3G.2.2.2 NI20 Model [needs to be fixed in Rev.18]

(Remove the word "are".)

[*The NI20 coarse model has fewer nodes and elements than the NI10 model. It captures the essential features of the nuclear island configuration. The nominal shell and solid element dimension is about 20 feet. It is used in the soil-structure interaction analyses of the nuclear island ~~are~~ performed using the program SASSI. The stick models are the same as used for the NI10 model except that the core makeup tank is not included. This model is shown in Figures 3G.2-11 and 3G.2-12*.]* Results of fixed base analyses of the NI20 model were compared to those of the NI10 model to confirm the adequacy of the NI20 model for use in the soil-structure-interaction analyses.

<u>Item 35</u> - 3G.2.3 Static Models [needs to be fixed in Rev.18]

(Complete Revision is needed. (1) Accurately describe the models that were actually used for static analysis (i.e., the ¼ refined model of the SB roof, the detailed 3-D model of the containment vessel including penetrations, the axisymmetric model of the containment vessel, and static models used for the basemat evaluation). (2) Create a

new subsection for the NI05 model, comparable to the subsections for the NI10 and NI20 models. Comparable information needs to be designated Tier 2* in the revision of this subsection and in the new subsection.)

Member forces in the ASB are obtained from analyses of a model that is more refined than the finite element model described in subsection 3G.2.1.1. This model is developed by meshing one area of the solid model with four finite elements. The nominal element size in this auxiliary building model is about 4.5 feet so that each wall has four elements for the wall height of about 18 feet between floors. This finite element shell model is referred to as the NI05 model. This refinement is used to calculate the design member forces and moments using response spectra analysis of the nuclear island models with seismic input enveloping all soil conditions. The finite element shell model of the containment internal structures described in subsections 3G.2.1.2, which includes the basemat within the shield building and the containment vessel stick model, is also included.

Item 36 - 3G.4.1 ANSYS Fixed Base Analysis

The NI10 model described in subsection 3G.3.2.2.1 was analyzed by time history modal superposition. To perform the time history analysis of this large model, the ANSYS superelement (substructuring) techniques were applied. Substructuring is a procedure that condenses a group of finite elements into one element represented as a matrix. The reasons for substructuring are to reduce computer time of subsequent evaluations. Two sets of analyses were performed. To obtain the time history response of the ASB, the ASB finite element model was merged with the superelement of the CIS and its major components. To obtain the time history response of the CIS, the CIS finite element model was merged with the superelement of the ASB.

Deflection time history responses were obtained at selected representative locations. These locations included major wall and floor intersections and nodes at the cardinal orientations at key elevations of the shield building. Nodes were also selected at mid-span on flexible walls and floors. Typical locations are shown for the ASB at elevation 135′ on Figures 3G.4-1 and 3G.4-2. Figure 3G.4-1 shows the “rigid” locations, and Figure 3G.4-2 shows the “flexible” locations.

[*ANSYS is used to calculate the maximum relative deflection to the nuclear island for the envelope case that considers all of the soil and hard rock site cases. Synthesized displacement time histories are developed using the envelope seismic response spectra from the six site conditions (hard rock, firm rock, soft rock, upper-bound-soft-to-medium, soft-to-medium, and soft soil). Seismic response spectra at nine locations are used (four edge locations, one center location, and four corner locations). It is not necessary to adjust for drift since relative deflections to the basemat are calculated and the drift would be subtracted from the results.*]*

Item 37 - 3G.4.2 3D SASSI Analyses

The computer program SASSI 2000 is used to perform Soil-Structure Interaction analysis with the NI20 Coarse Finite Element Model. The SASSI Soil-Structure Interaction analyses are performed for the five soil conditions established from the AP1000 2D SASSI analyses. These soil conditions are firm rock, soft rock, soft-to-medium soil, upper bound soft-to-medium, and soft soil. [*The model includes a surrounding layer of excavated soil and the existing soil media as shown in Figures 3G.4-3 and 3G.4-4.*]* Acceleration time histories and floor response spectra are obtained. Adjacent structures have a negligible effect on the nuclear island structures and, thus, are not considered in the 3D SASSI analyses. Westinghouse has adopted the approach that calculates displacements internally within the ACS SASSI program based on an analytical complex frequency domain approach that uses inverse Fast-Fourier Transforms (FFT) to compute relative displacement histories instead of double numerical integration in the time domain that computes absolute displacement time histories from absolute acceleration time histories.

In these analyses, the three components of ground motions (N-S, E-W, and vertical direction) are input separately. Each design acceleration time history (N-S, E-W, and vertical) is applied separately, and the time history responses are calculated at the required nodes. The resulting co-linear time history responses at a node due to the three earthquake components are then combined algebraically.

[*The relative displacement time history is calculated using ACS SASSI RELDISP module. The complex acceleration transfer functions (TF) are computed for reference and all selected output nodes. The relative acceleration transfer function is calculated by subtracting the reference node TF from the output node TF. The relative displacement transfer function is obtained by dividing the circular frequency square (ω²) for each frequency data point. The relative displacement time history is obtained by taking the inverse FFT.*

Relative displacements are calculated between adjacent buildings and the nuclear island using soft springs between the buildings. The spring stiffness is very small so that it does not affect the dynamic response. These calculations are performed using 2-D models and SASSI 2000. The relative deflection is calculated using the maximum compressive spring force and the stiffness value.]*

<u>Item 38</u> - 3G.4.3.1 Response Spectrum Analysis

[*The response spectrum methodology used in the AP1000 design employs the Complete Quadratic Combination (CQC, Section 1.1 of Reference 5) grouping method for closely spaced modes with the Der Kiureghian Correlation Coefficient (Section 1.1.3 of Reference 5) used for correlation between modes. The Lindley-Yow (Section 1.3.2, Reference 5) spectra analysis methodology is employed for modes with both periodic and rigid response components. The modal analysis performed to develop composite modal participation is used to develop input for the response spectrum analysis. Modes ranging from 0 to 33 Hz or higher are considered. For modes above the cutoff frequency, the Lindley-Yow is used. The Static ZPA Method (Section 1.4.2, Reference 5) is employed for the residual rigid response component for each mode as outlined in NRC Regulatory Guide 1.92 (Reference 5). The complete solution is developed via Combination Method B (Section 1.5.2, Reference 5). The combined effects, considering three spatial components of an earthquake (N-S, E-W, and Vertical), are combined by square root sum of the squares method (Section 2.1, Reference 5).*]*

<u>Item 39</u> - 3G.4.3.3 Seismic Response Spectra~~um~~ [needs to be fixed in Rev.18] (Yellow highlight is necessary revision. Also, Figure 3G.4-9Z is incorrect. It is the same as Figure 3G.4-9Y.)

[*The AP1000 plant floor response spectra~~um~~ for the six key locations is provided in Figure 3.G.4-5X to 3G.4-10Z. The bay locations are defined in Table 3G.4-1. The design seismic* *response spectra are conservatively adjusted in the low frequency range in anticipation of future sites having slightly higher response at the lower frequency.*]*

Item 40 - 3G.4.3.4 Bearing Pressure Demand

[*Bearing pressure demand was calculated using both 2D and 3D analyses. Both linear and non-linear analyses are performed with the 2D nuclear island model. The maximum bearing pressures calculated include the effect of dead, live, and seismic loading.*

The 2D model was used to evaluate the effect of liftoff on the bearing pressure. Since the largest bearing pressure will result from the east-west seismic excitation because of the smaller width of the basemat in this direction, liftoff was evaluated using an east-west stick model of the nuclear island structures, supported on a rigid basemat with non-linear springs. Direct integration time history analyses were performed. The bearing pressures calculated from these analyses are summarized in Table 3G.4-2. The pressures are at the edge of the basemat. Results are given for the three cases that result in the highest bearing pressure (hard rock [HR], upper bound soft to medium [UBSM] soil, and soft to medium [SM] soil). The linear results show maximum bearing pressures on the west side of 31 to 33 ksf. Liftoff increases the subgrade pressure close to the west edge by 4% to 6% with insignificant effect beneath most of the basemat.

The SASSI soil-structure interaction analyses are performed based on the nuclear island 3D SASSI model for the hard rock and five soil conditions established from the AP1000 2D SASSI analyses. The SASSI model of the nuclear island is based on the NI20 finite element model. The bearing pressures from the 3D SASSI analyses have been obtained by combining the time history results from the north-south, east-west, and vertical earthquakes. The maximum soil-bearing pressure demand is obtained from the hard rock (HR) case equal to 35 ksf. It is noted that a maximum localized peak is obtained on the west edge of 38 ksf; a limit of 35 ksf for maximum bearing seismic demand is obtained by averaging the soil pressure over 335 ft2 of the west edge of the shield building where the maximum stress occurs.]*

APPENDIX 3I

Item 41 - 3I.1 Introduction (3rd paragraph - designate following sentence as Tier 2*)

[The *results of the high frequency evaluation demonstrating that the AP1000 plant is qualified for this type of input are documented in a technical report (Reference 2).*]*

Item 42 - 3I.2 High Frequency Seismic Input (designate marked sentences as Tier 2*)

Presented in Figures 3I.1-1 and 3I.1-2 is a comparison of the horizontal and vertical HRHF envelope response spectra and the AP1000 CSDRS. [*The HRHF envelope response spectra presented are calculated at foundation level (39.5' below grade), at the upper most competent material and treated as an outcrop for calculation purposes*.]*

For each direction, the HRHF envelope response spectra exceed the design spectra in higher frequencies (greater than 15 Hz horizontal and 20 Hz vertical). The spectra are used for the HRHF envelope response spectra. [*If necessary, the HRHF envelope response spectra are enhanced at low frequencies so that HRHF envelope response spectra fully envelope all of the hard rock sites.*]*

[*This HRHF envelope response spectra is further limited in that the shear wave velocity limitation is defined at the bottom of the basemat equal to or higher than 7,500 fps, while maintaining a shear wave velocity equal to or above 8,000 fps at the lower depths.*]*

Item 43 - 3I.3 NI Models Used To Develop High Frequency Response [needs to be fixed in Rev.18]

Revise the first paragraph, quoted below, to
(1) describe the treatment of flexible areas using NI05, per TR-115;
(2) delete the discussion about NI20 being good to 80 Hz; and
(3) delete the discussion that this was confirmed by comparison to NI10.
Note: Neither model is good to 50 Hz.

"The NI20 nuclear island model described in Appendix 3G is analyzed in SASSI using the HRHF time histories applied at foundation level to obtain the motion at the base. The NI20 Model has sufficient mesh size to transmit the HRHF input up to 80 Hz. This was confirmed by comparing the dynamic response of the NI20 to that of the NI10 model, a model of much finer mesh. The NI20 model is used for responses above 10 hertz, as it has higher (conservative) results in the high frequencies compared to the NI10 model. However, the NI10 model gives more accurate results and is used in the fixed base analyses for hard rock."

Item 44 - 3I.4 Evaluation Methodology (designate 2nd and 3rd paragraphs as Tier 2*)

[*The high frequency seismic analyses that are performed use time history or broadened response spectra. The analysis is not performed using the combination spectra of the CSDRS and the HRHF envelope response spectra. Separate analyses with each spectra are used.*]*

[*The high frequency seismic analyses used the soil structure interaction code ACS SASSI. The results presented in this report are based on the stochastic (multiple, statistical analyses) seismic incoherent soil structure interaction (SSI) analysis approach referred herein as the simulation approach.*]*

Item 45 - 3I.7 References (designate Reference 2 as Tier 2*)

[*2. APP-GW-GLR-115, "Effect of High Frequency Seismic Content on SSCs," Westinghouse Electric Company LLC.*]*