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Your ref: Docket No. 52-006
Our ref: DCP/NRC1599

June 24, 2003

SUBJECT: Transmittal of Westinghouse Responses to Open Items Identified in the AP1000 Draft Safety Evaluation Report

This letter transmits Westinghouse responses to open items identified in the AP1000 Draft Safety Evaluation Report (DSER) that was issued on June 16, 2003. A list of the DSER Open Item responses that are transmitted with this letter is provided in Attachment 1. Attachment 2 provides the DSER Open Item responses.

Please contact me if you have questions regarding this transmittal.

Very truly yours,

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

/Attachments

1. Table 1, "List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1599"
2. Westinghouse Non-Proprietary Responses to US Nuclear Regulatory Commission DSER Open Items dated June 24, 2003

D063

DCP/NRC1599
Docket 52-006

June 24, 2003

Attachment 1

"List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1599"

Attachment 1

Table 1

"List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1599"

1.1-1	17.3.2-3
1.9-1	17.3.2-4
1.10-1	
	19.1.10.2-6
3.5.1.3-1	19.3.3-1
3.7.2.3-1	19.3.7-1
3.8.4.2-1	
	19A.2-1
10.2.8-2	19A.2-3
	19A.2-4
14.2-1	19A.2-8
	19A.2-9

DCP/NRC1599
Docket 52-006

June 24, 2003

Attachment 2

Westinghouse Non-Proprietary Response to
AP1000 Draft Safety Evaluation Report (DSER) Open Items

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 1.1-1

Original RAI Number(s): None

Summary of Issue:

Unless otherwise noted, this report is based on DCD Revision 3, dated February 6, 2003. Westinghouse has provided Revision 4 to the DCD dated April 15, 2003, and Revision 5 to the DCD dated May 19, 2003. The staff's review of these revisions to determine their impact on the conclusions in this report is Open Item 1.1-1

Westinghouse Response:

Westinghouse has submitted DCD Revision 6, dated June 23, 2003. This revision incorporates updates resulting from responses to NRC requests for additional information that were submitted subsequent to the issuance of DCD Revision 5, and prior to the NRC issuance of the DSER on June 16, 2003.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 1.9-1

Original RAI Number(s): None

Summary of Issue:

The staff has not yet identified all of the Tier 2* information pertaining to the AP1000 design. This effort will be completed to support the final safety evaluation report. This is DSER Open Item 1.9-1.

Westinghouse Response:

Westinghouse has identified the Tier 2* information in the AP1000 DCD based on that information that was identified as Tier 2* for the AP600. In addition, Westinghouse has identified additional Tier 2* information based on requests by the NRC during the current AP1000 review.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **1.10-1**

Original RAI Number(s): **None**

Summary of Issue:

Westinghouse included a summary of COL action items in Design Control Document (DCD) Tier 2 Table 1.8-2, and provided an explanation of the items in the applicable sections of the DCD. The staff identified a number of COL action items that resulted from its review throughout this Report. A cross-reference of the COL action items will be provided in Appendix F of the final safety evaluation report. The staff has not yet completed the cross-reference of the COL action items. This is DSER Open Item 1.10-1.

Westinghouse Response:

Westinghouse has identified the COL action items in the AP1000 DCD. The COL action items are consistent with the COL action items that were required for the AP600. In addition, Westinghouse has identified additional COL action items as appropriate to account for differences in the AP1000 design, differences in the scope of the AP1000 Design Certification, and NRC requests for additional information. The COL action item cross-reference table is included in DCD Section 1.8.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **3.5.1.3-1**

Original RAI Number(s): **251.002, 251.002**

Summary of Issue:

The methodology and analytical results of the probability of turbine missile generation are contained in the applicant's submittals, including WCAP-15783, and WCAP-15785. The NRC staff requested information in RAI 251.001 about the modifications made to the current turbine missile methodology from methodologies previously approved by the staff. In the response to RAI 251.001, the applicant did not directly provide the information requested regarding changes from previously approved methodologies. However, the staff performed a detailed review to identify and evaluate the modifications made to the previously approved turbine missile methodologies; therefore, RAI 251.001 is considered to be closed. Staff evaluation of these modifications is discussed below.

WCAP-15783 evaluated four potential failure mechanisms: (1) ductile burst from destructive overspeed; (2) fracture from HCF cracking; (3) fracture from LCF cracking; and (4) fracture from SCC. WCAP-15783 concludes that ductile burst will not occur before destructive overspeed is reached (the probability of reaching destructive overspeed is discussed in WCAP-15785). Also, the applicant concluded that the effect due to HCF cracking and LCF cracking can be ignored because of their extremely low probabilities of generating turbine missiles.

Notwithstanding the applicant's probability argument, the staff reviewed this information and determined that the applicant's evaluation methodology and results for the ductile failure from overspeed and HCF cracking are consistent with approved methodologies, and is therefore acceptable. The evaluation methodology for fracture from LCF cracking is similar to that previously reviewed in approved methodologies. The NRC staff evaluated the two parameters, Co and n, in the Paris fatigue crack growth rate equation, $da/dN= Co(K)^n$, which the applicant used in the LCF analysis and found them acceptable because they were derived from test and actual plant data. Although the data set is limited, this is acceptable to the staff because a very conservative fracture toughness is used for the disk material in the evaluation. The NRC staff has also examined the failure equation and determined that it is based on fracture mechanics using the acceptable Paris fatigue crack growth rate discussed above. Further, except for the maximum undetectable crack size, the values of all remaining deterministic parameters such as flaw shape factor, critical crack depth, and cyclic stress range are conservative, in that the flaw shape factor corresponds to a more conservatively assumed flaw shape than industry data reveals; the critical crack depth corresponds to a very conservative K_{IC} value; and the cyclic stress range corresponds to stresses at running speed and design overspeed of 120 percent, which are the peak stresses during a start-up cycle. Therefore, these values are acceptable to the NRC staff. Consequently, the NRC staff requested in RAI 251.002 that the applicant justify the use of the specified value for the maximum undetectable crack size. In the response to RAI 251.002, the applicant provided a value for the maximum undetected flaw size but did not provide a basis for the maximum undetected flaw size. This is Open Item 3.5.1.3-1. The staff's evaluation of LCF cracking applies to Section 10.2.3 of this report.

Westinghouse Response:

This question was originally identified as RAI OI-251.002 Rev. 1. Westinghouse provided a response to RAI OI-251.002 Rev. 1, which was originally transmitted to the NRC via DCP/NRC1565 dated 04/04/03.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **3.7.2.3-1**

Original RAI Number(s): **230.020, 230.021, 230.022**

Summary of Issue:

During the audits conducted on November 12, 2002, and April 2, 2003, the staff discussed with the applicant the development of the dynamic model of the NI structures and reviewed the applicant's analysis reports based on both 3D lumped-mass stick model and 3D finite element model. The seismic analysis results from the 3D finite element model of the coupled auxiliary/shield building shows net tension in the shield building wall. This phenomenon suggests that during the postulated seismic event, parts of the basemat will lift up from the rock surface resulting in changes in the basemat stresses and reduction of shear wall stiffnesses due to reinforced wall cracking. As a result of the detailed review of the seismic modeling approach and analysis methods, the staff identified an issue that the assumptions of uncracked reinforced concrete walls and fixed-base foundation may become invalid. With this finding, the applicant was requested to provide justification to show that the current seismic analysis results used for the design of the NI structures, systems and components are reasonable and acceptable.

In resolving this issue, the staff, during the meeting conducted on April 2, 2003, explained its concern and expectation to the applicant regarding the significance of uplift due to seismic excitation of the NI and the effect of reduction of stiffness of shear walls. The discussion reached the following conclusions:

- The applicant will use East-West lumped-mass stick model of the NI structures supported on a rigid plate with nonlinear springs that transmit reactions in horizontal and vertical directions to simulate the foundation contact area, and perform a seismic time history analysis (the nonlinear springs will be in action only when the rigid plate is in contact with the subgrade). The results of this seismic time history analysis will be compared against the peak accelerations and the floor response spectra at the lumped mass node points obtained from the current three dimensional model analysis without the uplift consideration. If the comparison shows differences, the applicant should evaluate the significance of these differences and their effects on the current seismic design.

- With regard to the effect of shear wall stiffness reduction (due to shear wall cracking) on the seismic analysis results (natural frequencies, peak floor accelerations and the floor response spectra), the applicant will consider using a three dimensional (3D) lumped mass stick model with reduced member stiffnesses to conduct a time history seismic analysis. Results from this analysis will be compared against those currently used by the applicant for the design of the NI structures, systems and components. If the comparison shows differences, the applicant should evaluate the significance of these differences and their effects on the current seismic design.

When the final seismic analyses are performed for the NI structures, the applicant should incorporate the two above discussed effects in the final seismic model for calculating seismic responses. These seismic responses should also be compared against those currently used for the seismic design. If the comparison shows differences on the order of 10 percent or less, the combined effect of uplifting and shear wall cracking will be considered as insignificant. Otherwise, the seismic loads used for the design will have to be revised accordingly.

Depending on the outcome of the comparisons from the two separate analyses discussed above, one for the uplift effect and the other for stiffness reduction, the design calculations for the certified design may have to be revised. This is Open Item 3.7.2.3-1.

Westinghouse Response:

The effects of basemat uplift and shear wall stiffness reduction due to shear wall cracking have been evaluated using seismic time history analyses. Peak accelerations, floor response spectra, and member forces from seismic time history analyses that included basemat uplift and shear wall stiffness reduction effects were compared to seismic time history analyses that did not include these effects. The comparisons described in part A below show that the basemat uplift effect is insignificant. The shear wall stiffness reduction is more significant as described in part B of below and affects the peak accelerations, the floor response spectra, and time history member forces. The DCD is revised to describe these analyses. The final design of the AP1000 critical sections will address the changes in response when the maximum absolute accelerations in the stick models increase by more than 10% or when the existing calculations consider amplification due to flexibility.

A. Liftoff Analysis

<u>Liftoff Model</u>

The effect of liftoff was evaluated using an East-West lumped-mass stick model of the nuclear island structures supported on a rigid basemat with nonlinear springs. This model is shown in Figure 3.7.2.3-1-1 and Figure 3.7.2.3-1-2. The liftoff analysis model consists of the following two submodels or element types:

1. The nuclear island (NI) combined stick model (ASB, CIS and SCV)
2. The rigid basemat model with horizontal and vertical rock springs

The size of the equivalent rectangular basemat having the same overturning inertia as the nuclear island basemat is 140.0' × 234.5'. The basemat is modeled as a rigid beam, using 20 elements, each 7 feet apart. Hard rock with a shear wave velocity of 8000 feet per second is modeled as horizontal and vertical spring elements with viscous damping at each node of the rigid beam. As shown in Figure 3.7.2.3-1-2, the NI combined stick is attached to the rigid

basemat at the NI gravity center, which is about 9 feet from the center of the rigid basemat. In north-south direction, the stick is fixed at the bottom (EL. 60.5').

Time history analyses are run by direct integration for dead load plus safe shutdown earthquake for two cases:

> "*rocks_di*" with linear rock springs able to take both tension and compression
>
> "*Liftoff*" with non-linear rock springs where the vertical springs act in compression only and the horizontal springs are active when the vertical spring is closed and inactive when the vertical spring lifts off.

The "rocks_di" and the "Liftoff " models use the same damping for the soil and for the buildings. The soil damping is calculated using ASCE-98 equations and applied as a damping value to the rock springs elements. For the building elements, damping is included as mass and stiffness proportional damping matching 7% modal damping at frequencies of 3 and 25 Hertz.

Maximum Member Forces and Moments

Table 3.7.2.3-1-1 shows the maximum member forces and moments. Elements 1 to 303 are in the auxiliary and shield building. Elements 401 to 416 are in the containment vessel and elements 500 to 508 are in the containment internal structures. The results show that the liftoff has insignificant effect on the maximum member forces and moments..

Floor Response Spectra

Figure 3.7.2.3-1-3 through Figure 3.7.2.3-1-7 show the floor response spectra in the horizontal and vertical directions at representative elevations of the auxiliary and shield building. The results show that the liftoff effect on the response spectra is insignificant, especially in the horizontal direction. In the vertical direction, especially at the lower elevation, the liftoff effects are visible in the frequency range from 10 to 25 Hz. However the liftoff effect in this range and on the ZPA (zero period acceleration) is insignificant.

Figure 3.7.2.3-1-3 through Figure 3.7.2.3-1-7 also show the case where the soil stiffness has been reduced by 50 percent. This is equivalent to the soil having a shear wave velocity of about 5600 fps. The results show that reducing the soil stiffness leads to lower building response. This is due to the larger displacement of the basemat in the reduced soil stiffness case leading to larger basemat velocities and thus damping in the reduced stiffness soil springs.

Subgrade Pressure and Basemat Displacements

Figure 3.7.2.3-1-8 shows the maximum dynamic subgrade pressure during the analysis. Figure 3.7.2.3-1-9 shows the time history of the pressure at the west and east edges around the time that the peak pressure occurs at the west edge. Lift off has a small effect on the subgrade pressures close to the west edge with insignificant effect beneath most of the equivalent rectangular basemat. The effect on the pressure at the west edge is significantly less than that

calculated in the basemat analyses using equivalent static accelerations. Figure 3.7.2.3-1-10 shows two time history basemat displacements, one that occurs at the time of maximum lift off and one that occurs at the time of maximum soil pressure. These time history displacements are compared to basemat displacements equivalent static analyses. The upper figure shows linear (no lift-off effect) analysis results and the lower figure shows non-linear (lift-off effects) analysis results. In the linear analyses, the differences between dynamic and static displacements are small. The differences are larger in the non-linear analyses. The table below shows the seismic overturning moments and vertical forces in the equivalent static analyses and in the time history analyses at the time that peak pressure occurs at the west edge.

	static (+1.0ew-0.4vt)	*rocks_di* (t=5.685 sec)	Ratio *rocks_di/static*	*liftoff* (t=5.685 sec)	Ratio *liftoff/static*
Vertical Force (kips)	-4.59E+04	-4.69E+04	1.022	-4.64E+04	1.011
Overturning Moment (kips-ft)	1.36E+07	9.04E+06	0.665	9.03E+06	0.664

The overturning moment in the equivalent static analyses is 50% higher than in the dynamic analyses. This conservatism is also seen in Table 3.7.2.3-1-6 and 3.7.2.3-1-8. Thus, the static results from linear analyses using the 100-40-40 method are much more conservative than the dynamic result from non-linear analyses.

B. Reduced Shear Wall Stiffness

The effects of shear wall stiffness reduction (due to shear wall cracking) were evaluated by changing the concrete modulus in the auxiliary and shield building and the containment internal structure in the nuclear island time history seismic analyses. The stiffness properties are reduced by a factor of 0.8 to consider the effect of cracking as recommended in Table 6-5 of FEMA 356. The revised models also include the changes described in response revision 3 to RAI 230.018.

The results from the seismic time history analyses, including the shear wall stiffness reduction effects, were compared to results of the seismic time history analyses included in DCD Revision 3 that did not include these effects. The comparison, which is discussed further in subsequent paragraphs, shows that the shear wall stiffness reduction affects the peak accelerations, the floor response spectra, and time history member forces. The reduced stiffness case is considered to provide a better estimate of response than the previous analyses with uncracked concrete. The DCD is therefore being revised to incorporate the results of the new analyses. Comparison tables are provided in this Open Item response together with evaluation of the effect on the structural design previously reviewed by the NRC staff.

Maximum absolute accelerations are compared in Table 3.7.2.3-1- 2 to Table 3.7.2.3-1- 4. The differences are due to the reduction in stiffness as well as to the changes in the model described in the response to RAI 230.018.

Member forces in the revised time history analyses are compared in Tables 3.7.2.3-1- 1 to

Table 3.7.2.3-1-7 against those from a static analysis of the revised stick model using the equivalent static accelerations used in the auxiliary building equivalent static analyses. The results show that the equivalent static analysis is still conservative for the member forces in the stick model for the Auxiliary and Shield Building and for the Containment Internal Structures. These member forces provide a good measure of the effect on the in-plane seismic forces in the walls and floor slabs. Out-of-plane seismic forces are dependent on the maximum absolute acceleration. The shear wall design is generally controlled by in-plane seismic loads. The floors are generally controlled by normal loads. Final design of the critical sections will address the changes in response when the maximum absolute accelerations in the stick models increased by more than 10% or when the existing calculations consider amplification due to flexibility. The design calculation for nuclear island stability was reviewed and found to be acceptable for the changes in response.

The results show a small increase (up to 10%) in the accelerations for the SCV in the east-west direction and larger increases in the north-south and vertical directions (up to 20%). The overturning moments at the base of containment in the equivalent static analyses are 0.87 times those in the revised time history analysis. This increase in seismic response will be addressed in the response to DSER Open Item 3.8.2.1-1

Design Control Document (DCD) Revision:

1. Subsection 3.7.2.2, second paragraph, first two sentences are combined to read:

   The time history seismic analysis of the nuclear island considers 200 vibration modes, extending up to a frequency of 83.8 hertz as shown in Table 3.7.2-4.

2. Add new paragraph at end of subsection 3.7.2.3:

   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. When the finite element or stick models of these buildings are used in time history or response spectrum dynamic analyses, the stiffness properties are reduced by a factor of 0.8 to consider the effect of cracking as recommended in Table 6-5 of FEMA 356 (Reference 5).

3. In Section 3.7.6, reference 5 is added:

   "5. FEMA 356 – Pre-standard and Commentary for the Seismic Rehabilitation of Buildings, November 2000."

4. Revise Table 3.7.2-1 and Tables 3.7.2-4 to 3.7.2-13 to incorporate revised analyses results that include shear wall stiffness reduction.

5. Revise Figure 3.7.2-9, Figure 3.7.2-11, and Figures 3.7.2-15 to 3.7.2-17 to incorporate revised analyses results that include shear wall stiffness reduction.

PRA Revision:

None

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Table 3.7.2.3-1-1: Maximum Seismic Member Forces and Moments

Elem	Elevations		*rocks_di*			*liftoff*			Ratio *Liftoff/rocks_di*		
			Axial	Shear	M	Axial	Shear	M			
1	60.50	66.50	47.34	50.65	5020.9	46.58	52.94	4982.3	0.984	1.045	0.992
2	66.50	81.50	16.05	10.54	2634.2	15.76	10.83	2616.0	0.982	1.028	0.993
3	81.50	91.50	53.57	14.24	6474.3	52.10	14.31	6453.8	0.973	1.005	0.997
4	91.50	99.00	49.52	12.20	6340.9	48.23	11.96	6307.9	0.974	0.980	0.995
5	99.00	106.17	46.34	54.86	6253.7	45.22	54.49	6195.8	0.976	0.993	0.991
6	106.17	116.50	44.23	53.50	5884.3	43.25	53.18	5783.9	0.978	0.994	0.983
7	116.50	134.87	39.33	48.07	5366.4	38.71	48.04	5222.2	0.984	0.999	0.973
31	134.87	145.37	34.35	40.81	4592.7	34.15	40.87	4532.8	0.994	1.001	0.987
32	145.37	153.98	32.44	37.66	4210.7	32.39	37.75	4193.3	0.998	1.002	0.996
33	153.98	164.51	30.52	34.71	3929.2	30.34	33.80	3912.9	0.994	0.974	0.996
34	164.51	179.56	28.77	31.99	3591.0	28.64	30.84	3576.2	0.995	0.964	0.996
35	179.56	200.00	26.46	28.88	3110.1	26.44	28.75	3097.4	0.999	0.995	0.996
36	200.00	220.00	24.82	27.39	2482.6	24.80	27.26	2477.4	0.999	0.995	0.998
37	220.00	242.50	22.93	24.87	1918.2	22.85	24.82	1889.7	0.997	0.998	0.985
38	242.50	265.00	20.77	21.41	1337.2	20.68	21.13	1336.5	0.996	0.987	0.999
301	265.00	295.23	17.53	15.77	896.0	17.60	15.88	900.3	1.004	1.007	1.005
303	295.23	333.13	3.08	6.82	277.6	3.09	7.00	284.3	1.003	1.026	1.024
401	100.00	104.12	4.05	6.85	869.5	3.94	6.77	867.2	0.973	0.988	0.997
402	104.12	110.50	4.02	6.80	840.7	3.89	6.72	838.7	0.968	0.988	0.998
403	110.50	112.50	4.02	6.80	797.4	3.89	6.72	795.8	0.968	0.988	0.998
405	112.50	131.68	3.90	6.63	781.6	3.75	6.56	780.1	0.962	0.989	0.998
406	131.68	138.58	3.71	6.39	650.6	3.58	6.32	650.4	0.965	0.989	1.000
407	138.58	141.50	3.71	6.39	606.5	3.58	6.32	606.8	0.965	0.989	1.000
408	141.50	162.00	3.51	6.11	583.4	3.38	6.05	583.7	0.963	0.990	1.001
409	162.00	169.93	3.26	5.73	452.5	3.15	5.69	453.7	0.966	0.993	1.003
410	169.93	200.00	2.84	5.09	397.3	2.75	5.06	398.5	0.968	0.994	1.003
411	200.00	224.00	2.36	4.22	232.6	2.29	4.21	234.3	0.970	0.998	1.007
412	224.00	244.21	1.32	2.59	114.2	1.27	2.60	115.4	0.962	1.004	1.011
413	244.21	255.02	1.00	1.90	54.4	1.00	1.90	55.2	1.000	1.000	1.015
414	255.02	265.83	0.76	1.36	29.0	0.78	1.37	29.4	1.026	1.007	1.014
415	265.83	273.83	0.51	0.84	11.1	0.53	0.85	11.2	1.039	1.012	1.009
416	273.83	281.90	0.21	0.31	2.5	0.22	0.31	2.5	1.048	1.000	1.000
500	60.50	66.50	46.41	35.78	4344.1	45.66	37.40	4310.9	0.984	1.045	0.992
501	66.50	82.50	65.96	66.94	6267.2	64.75	67.80	6220.9	0.982	1.013	0.993
502	82.50	98.00	17.05	55.76	1668.4	17.07	55.30	1674.0	1.001	0.992	1.003
503	98.00	103.00	8.82	16.38	628.0	8.80	16.45	628.9	0.998	1.004	1.001
504	103.00	107.17	5.84	14.44	544.0	5.84	14.52	544.5	1.000	1.006	1.001
505	107.17	134.25	3.24	11.75	478.8	3.33	11.62	479.0	1.028	0.989	1.000
506	134.25	153.00	0.16	1.64	31.2	0.17	1.60	30.5	1.063	0.976	0.978
507	134.25	153.00	0.45	4.78	124.7	0.47	4.76	125.0	1.044	0.996	1.002
508	153.00	169.00	0.11	1.99	32.9	0.11	1.99	32.9	1.000	1.000	1.000

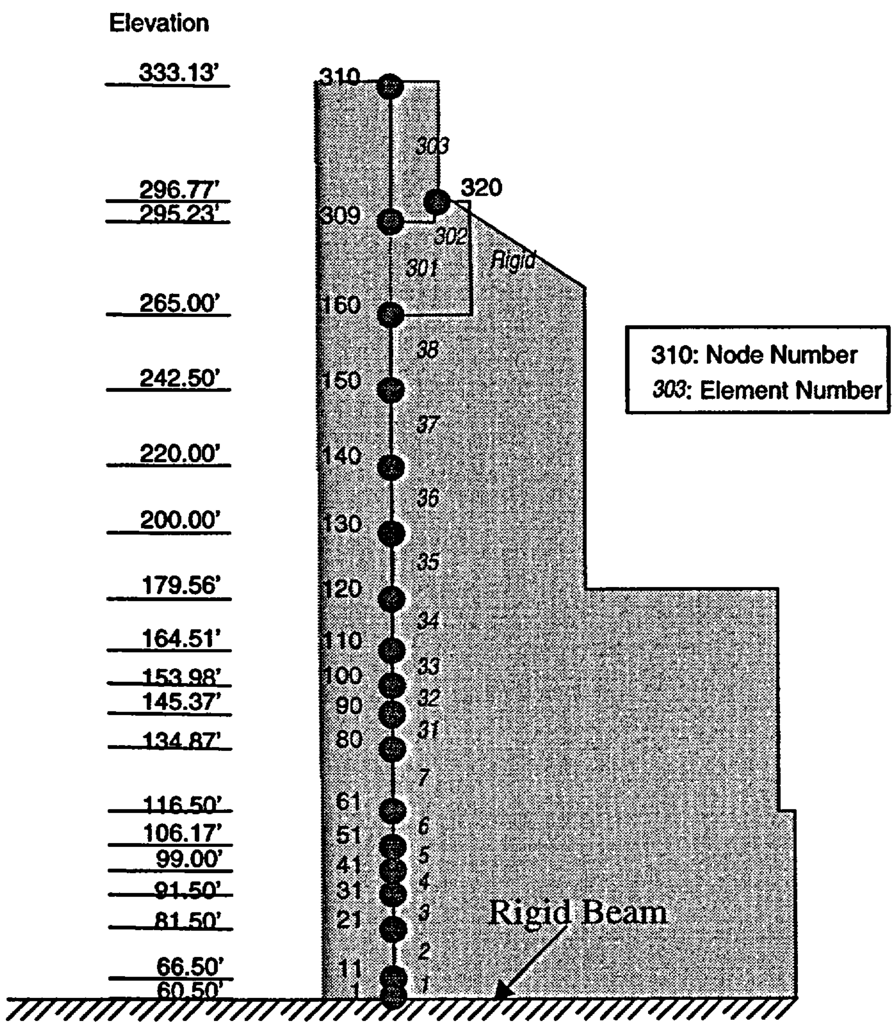


Figure 3.7.2.3-1-1: ASB Stick portion of NI combined model

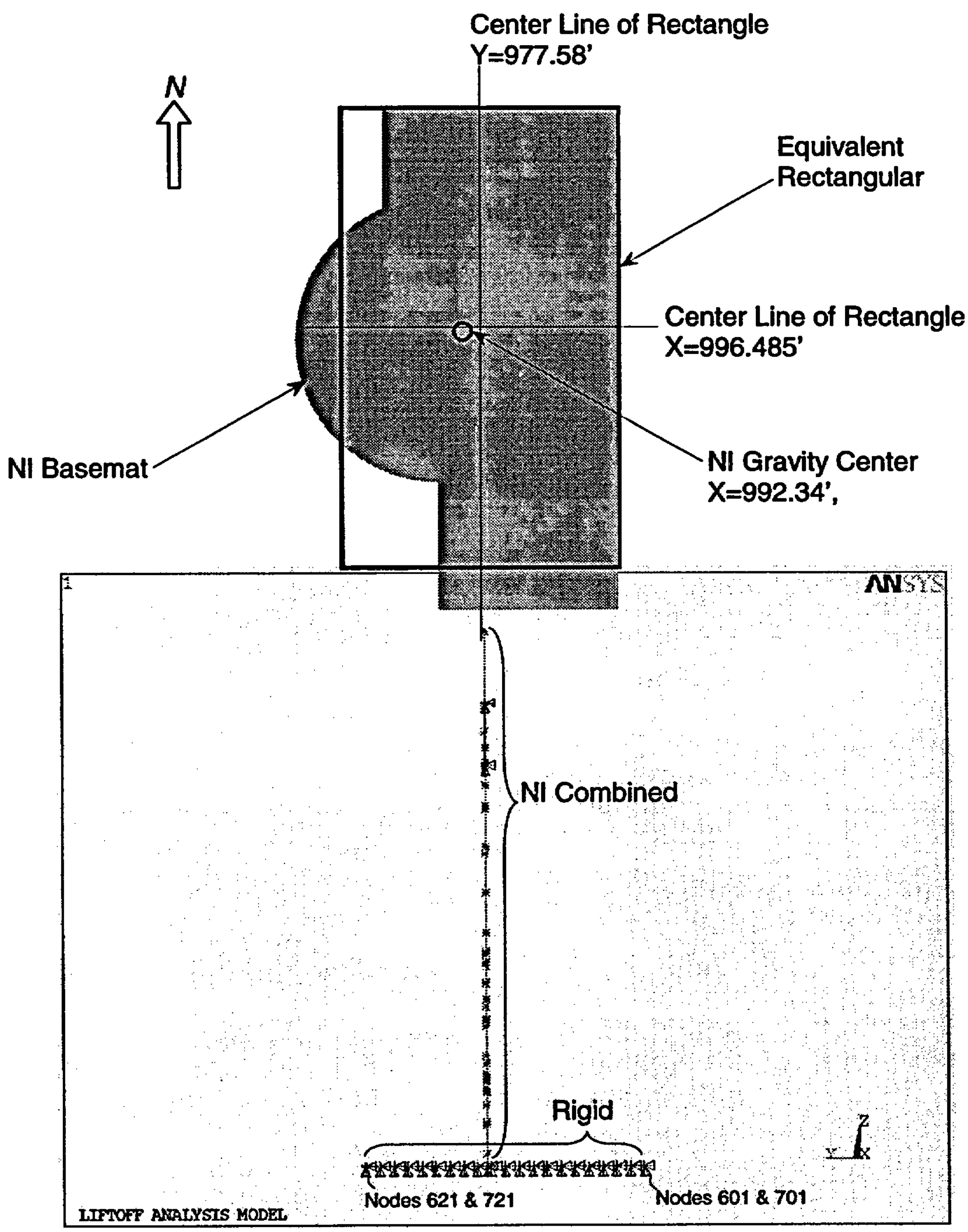
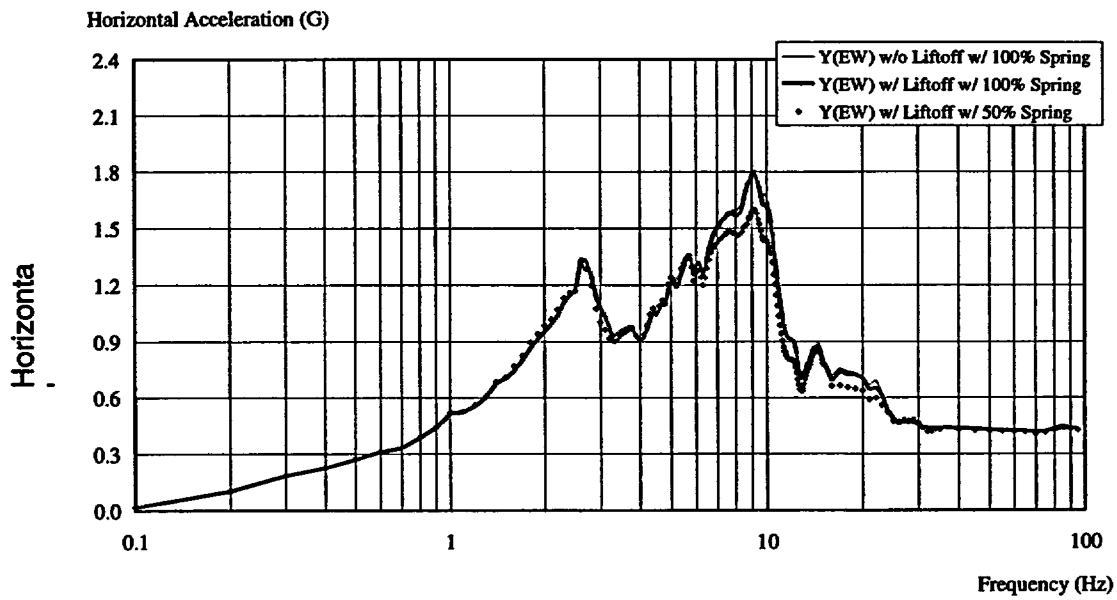


Figure 3.7.2.3-1-2: Rigid Basemat



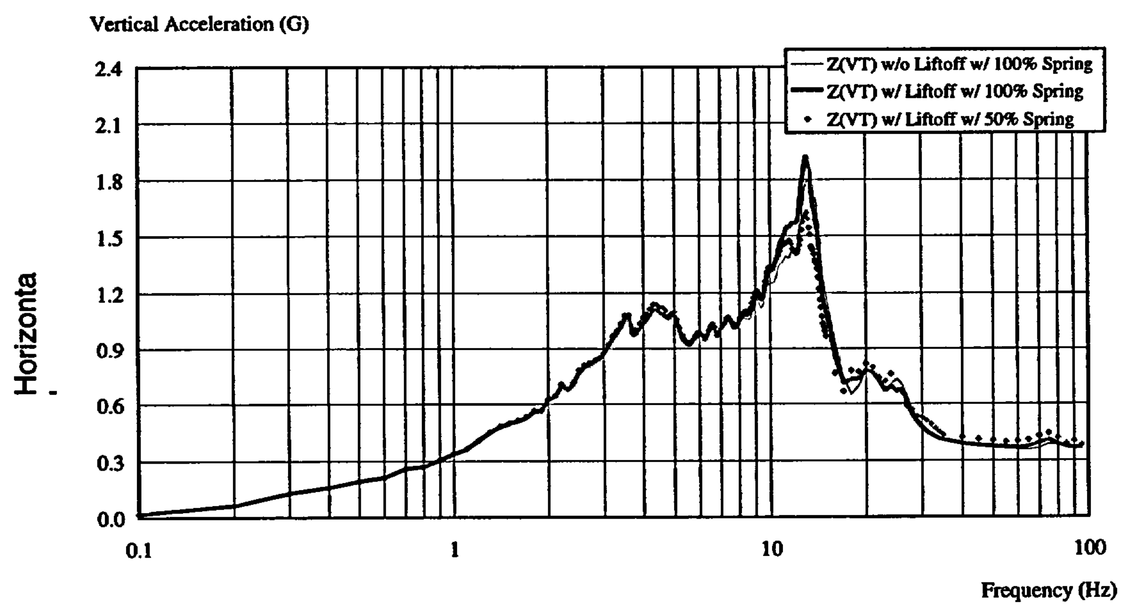
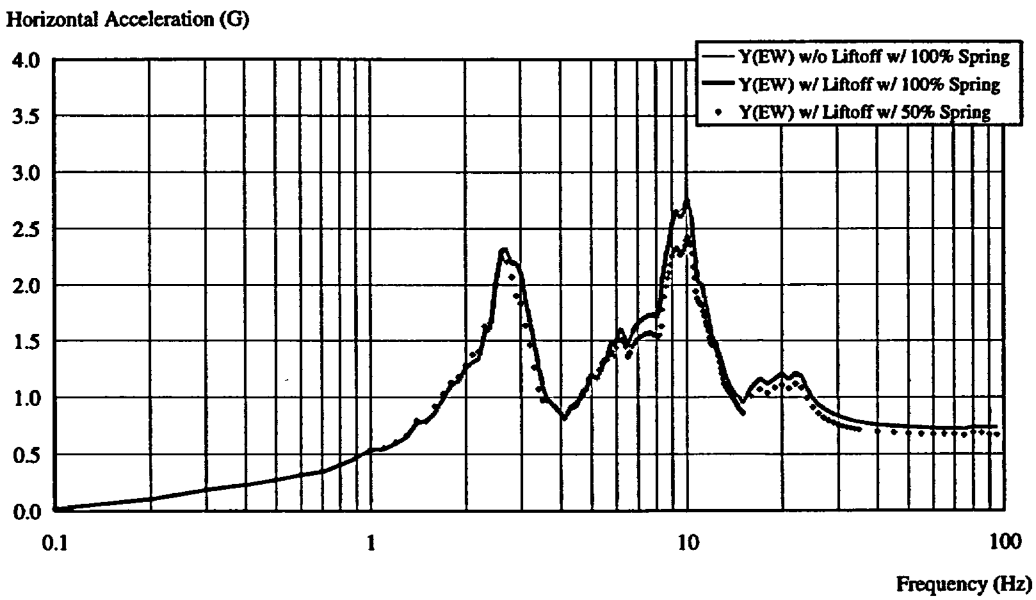


Figure 3.7.2.3-1-3:Floor Response Spectra at 5 % Damping – Node 61 (EL. 116.50')



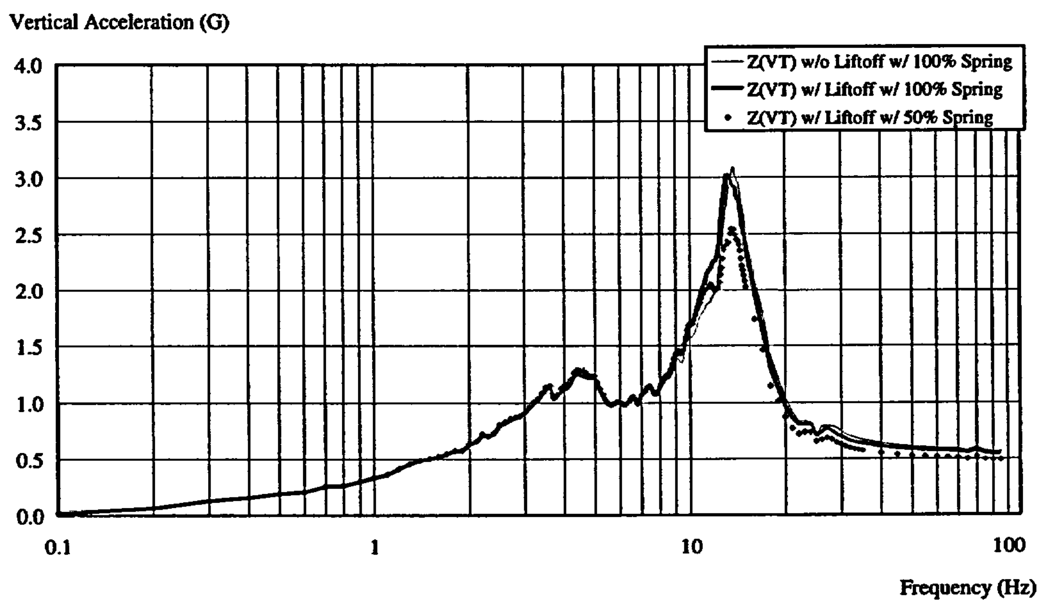
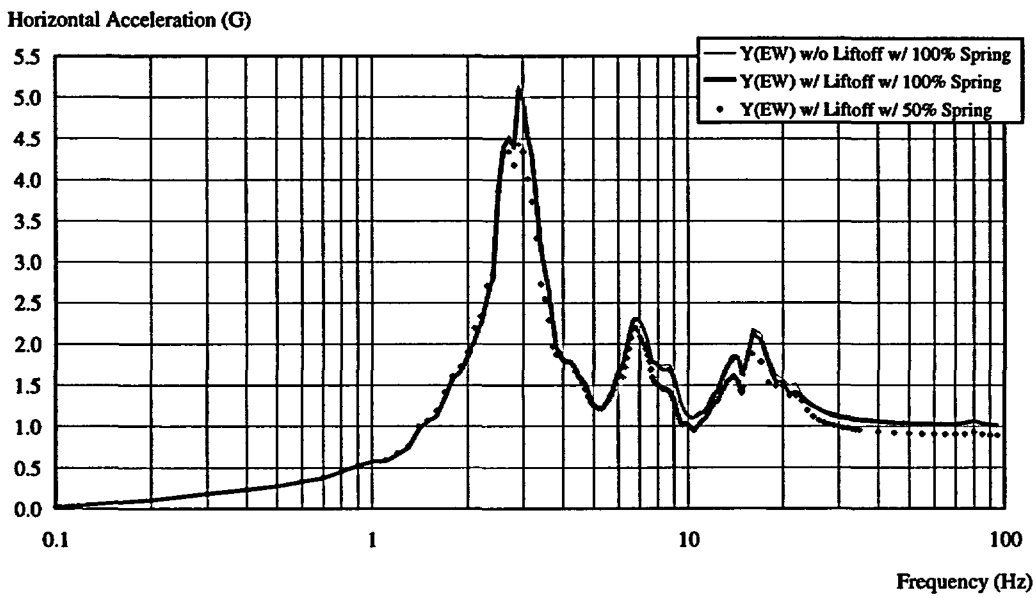


Figure 3.7.2.3-1-4: Floor Response Spectra at 5 % Damping – Node 120 (EL. 179.56')



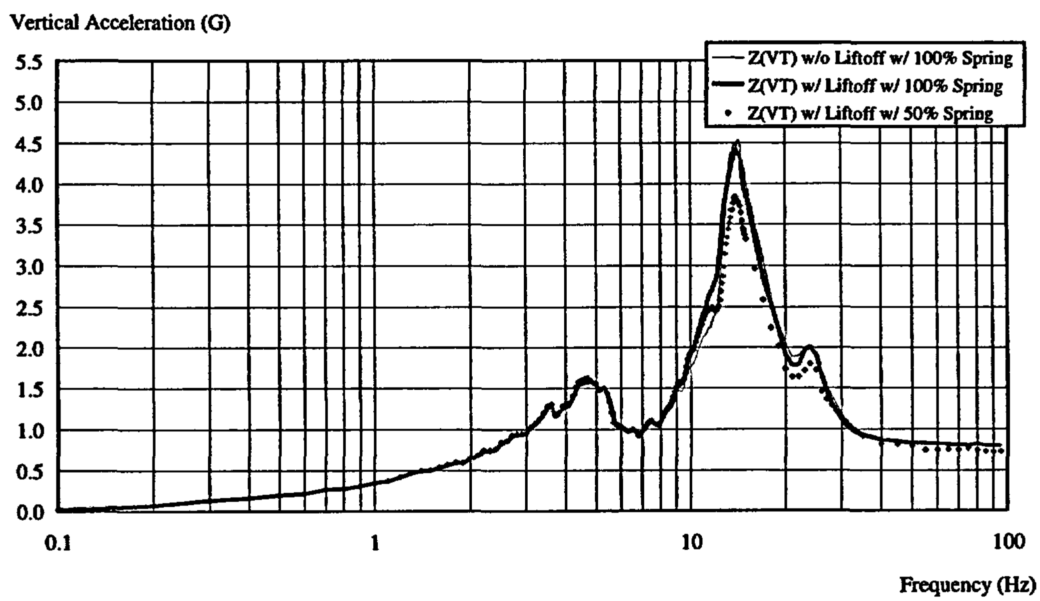
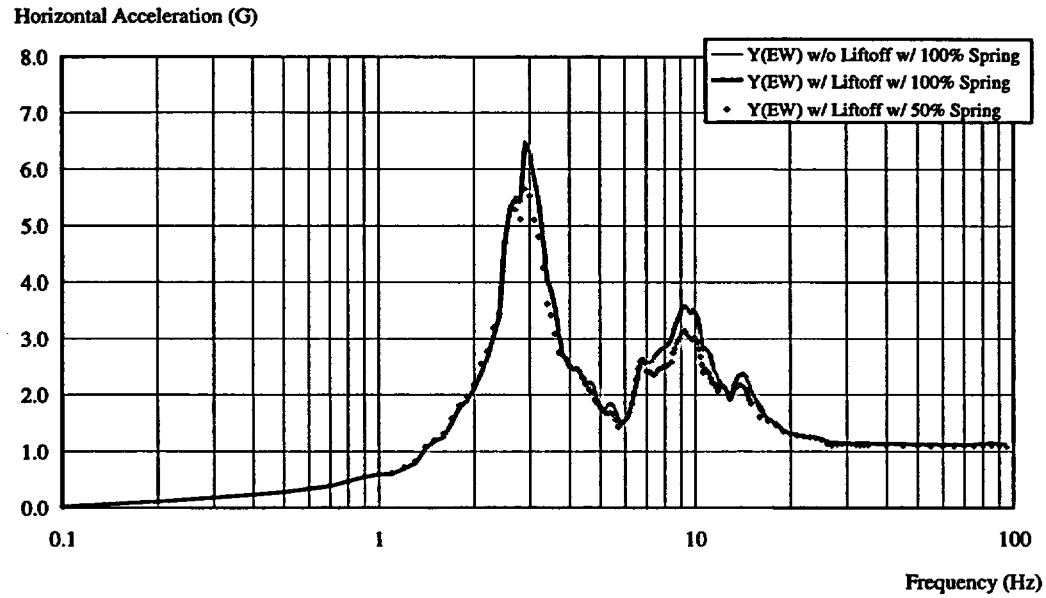


Figure 3.7.2.3-1-5: Floor Response Spectra at 5 % Damping – Node 160 (EL. 265.00')



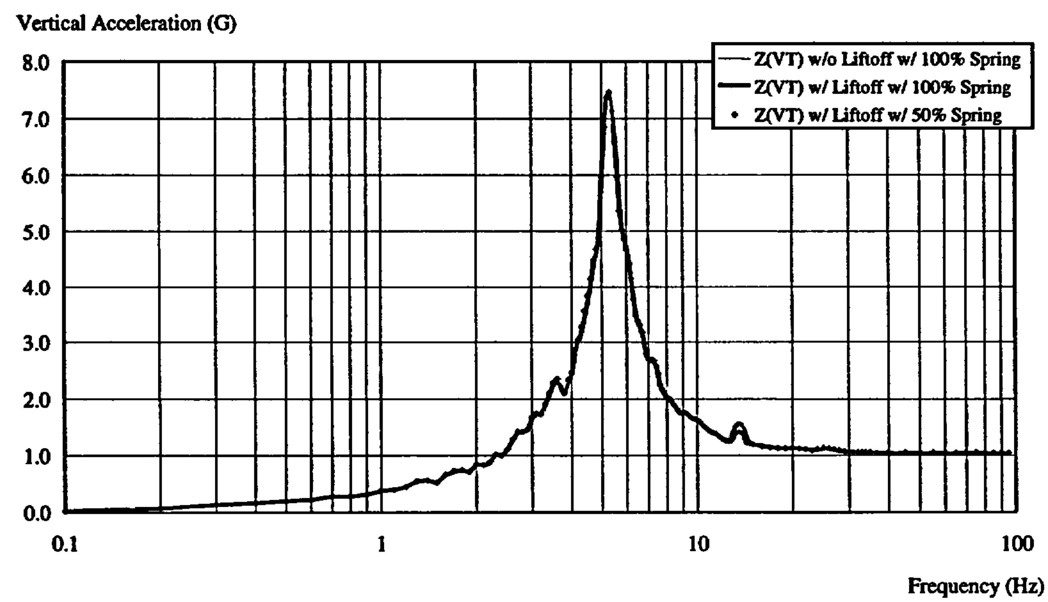
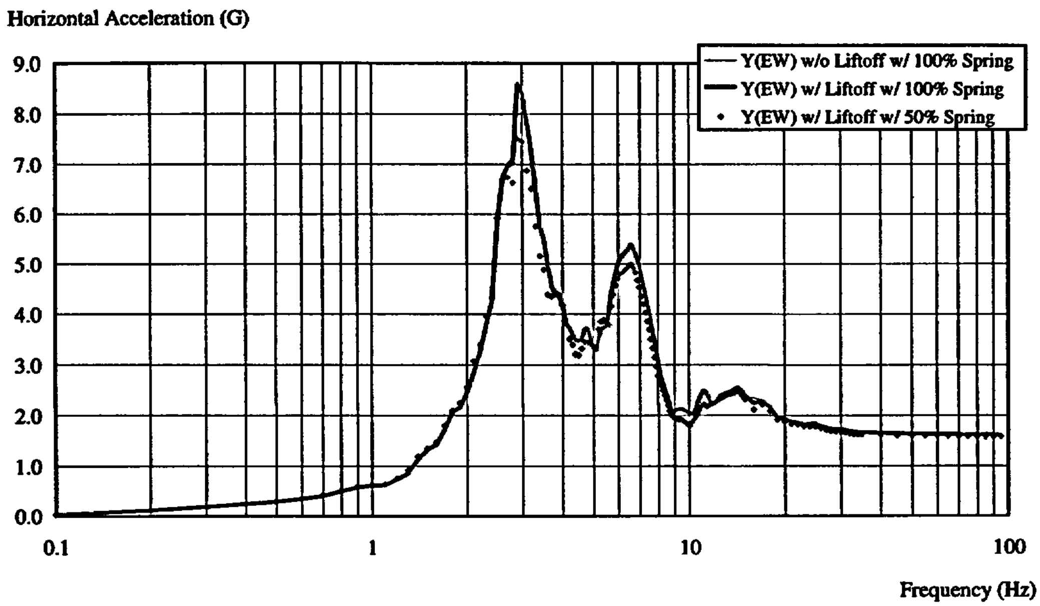


Figure 3.7.2.3-1-6: Floor Response Spectra at 5 % Damping – Node 309 (EL. 295.23')



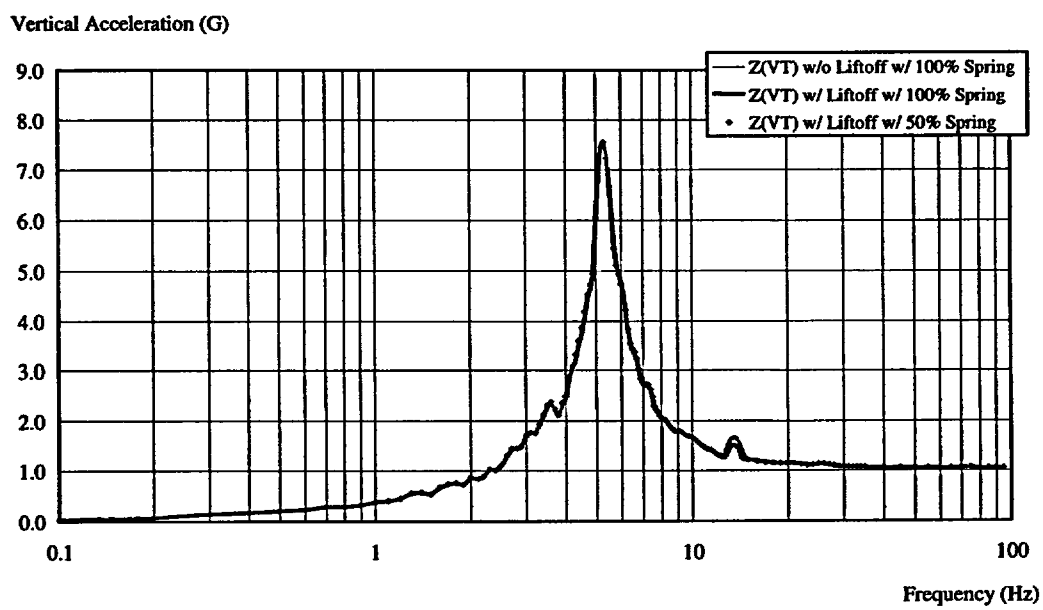


Figure 3.7.2.3-1-7: Floor Response Spectra at 5 % Damping – Node 310 (EL. 333.13')

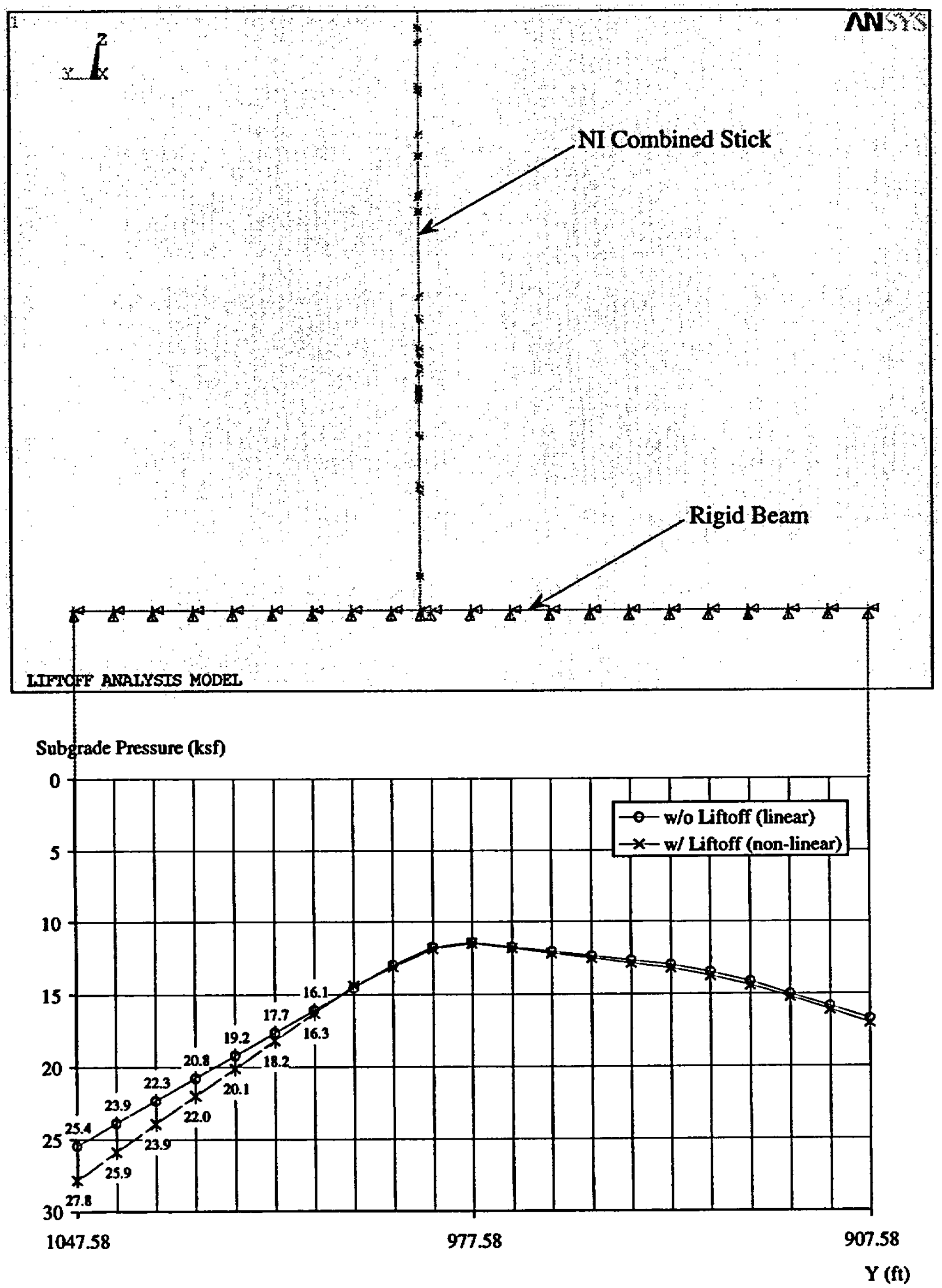


Figure 3.7.2.3-1-8: Maximum Dynamic Subgrade Pressure Distribution

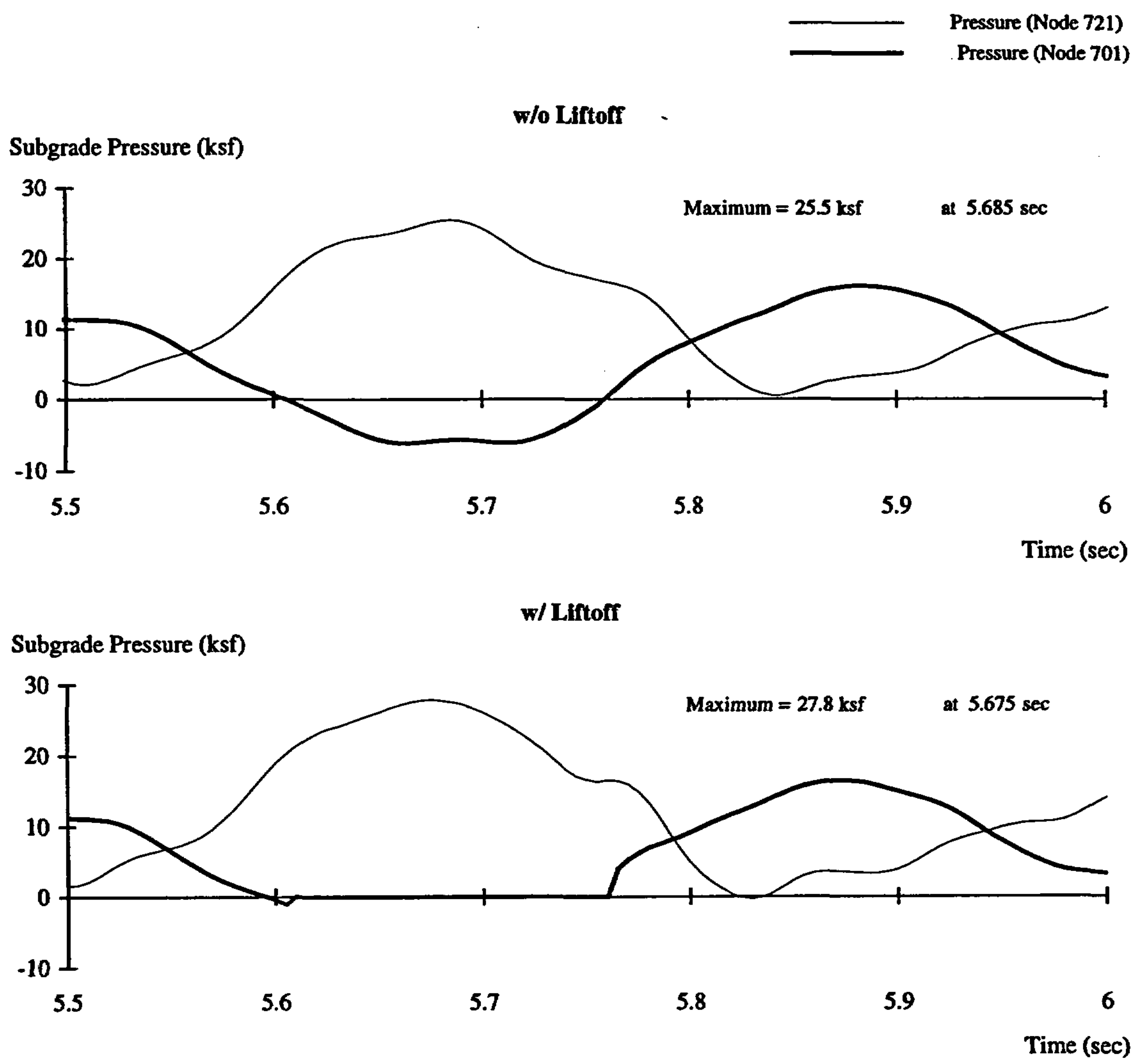


Figure 3.7.2.3-1-9: Time History of Basemat Edge Pressure

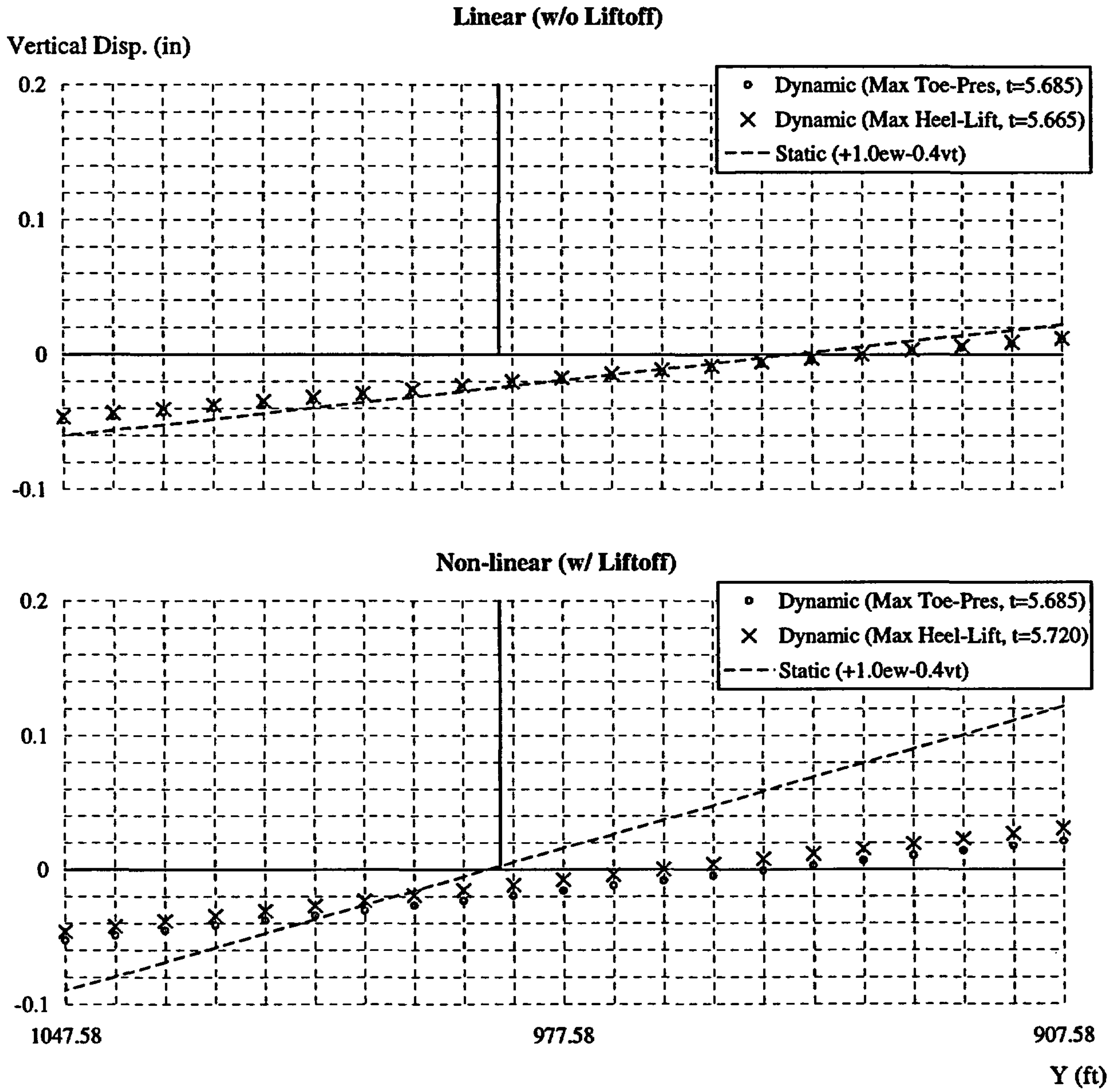


Figure 3.7.2.3-1-10: Basemat Displacements

Table 3.7.2.3-1-2: COMPARISON OF SEISMIC RESPONSES AUXILIARY AND SHIELD

MAXIMUM ABSOLUTE NODAL ACCELERATION (ZPA)
COUPLED AUXILIARY & SHIELD BUILDINGS

Elevation (ft)	Maximum Absolute Nodal Acceleration, ZPA (g)					
	N-S Direction		E-W Direction		Vertical Direction	
	100% E	80% E	100% E	80% E	100% E	80% E
333.13	1.36	1.46	1.77	1.51	0.96	1.01
295.23	1.07	1.12	1.24	1.10	0.95	1.00
265.00	0.9	0.91	0.9	0.97	0.58	0.71
242.50	0.81	0.81	0.82	0.89	0.56	0.69
220.00	0.74	0.71	0.75	0.80	0.52	0.65
200.00	0.68	0.71	0.7	0.77	0.48	0.59
179.56	0.6	0.76	0.71	0.78	0.43	0.52
164.51	0.55	0.73	0.69	0.75	0.39	0.48
153.98	0.53	0.70	0.67	0.73	0.39	0.44
134.87	0.5	0.60	0.59	0.63	0.39	0.41
116.50	0.45	0.50	0.47	0.50	0.34	0.37
99.00	0.37	0.39	0.41	0.40	0.33	0.34
81.50	0.32	0.33	0.33	0.33	0.31	0.31
66.50	0.3	0.30	0.3	0.30	0.3	0.30

Table 3.7.2.3-1-3: COMPARISON OF SEISMIC RESPONSES CONTAINMENT VESSEL

MAXIMUM ABSOLUTE NODAL ACCELERATION (ZPA)
STEEL CONTAINMENT VESSEL

Elevation (ft)	Maximum Absolute Nodal Acceleration, ZPA (g)					
	N-S Direction		E-W Direction		Vertical Direction	
	100% E	80% E	100% E	80% E	100% E	80% E
281.90	1.27	1.48	1.42	1.56	1.13	1.25
273.83	1.22	1.43	1.38	1.50	0.85	1.02
265.83	1.17	1.38	1.34	1.43	0.71	0.85
255.02	1.1	1.31	1.28	1.34	0.62	0.73
244.21	1.03	1.23	1.22	1.26	0.58	0.68
224.00	0.9	1.09	1.09	1.11	0.56	0.66
200.00	0.76	0.90	0.93	0.94	0.52	0.61
169.93	0.63	0.69	0.7	0.72	0.46	0.53
162.00	0.59	0.63	0.64	0.67	0.45	0.51
141.50	0.47	0.49	0.53	0.54	0.4	0.45
131.68	0.41	0.43	0.49	0.47	0.38	0.41
112.50	0.37	0.40	0.41	0.37	0.34	0.35
104.12	0.37	0.38	0.39	0.38	0.34	0.32
100.00	0.36	0.38	0.4	0.39	0.33	0.31

Table 3.7.2.3-1-4: COMPARISON OF SEISMIC RESPONSES AUXILIARY AND SHIELD

MAXIMUM ABSOLUTE NODAL ACCELERATION (ZPA)
CONTAINMENT INTERNAL STRUCTURES

Elevation (ft)	Maximum Absolute Nodal Acceleration, ZPA (g) N-S Direction		E-W Direction		Vertical Direction	
	100% E	80% E	100% E	80% E	100% E	80% E
169.00 (PRZ Compartment)	1.33	1.27	1.44	1.64	0.43	0.49
153.00 (SG-West Compartment)	0.73	0.75	0.65	0.71	0.39	0.42
153.00 (SG-East Compartment)	1.15	0.75	0.59	0.78	0.4	0.48
134.25	0.56	0.60	0.51	0.56	0.32	0.35
107.17	0.38	0.40	0.41	0.40	0.31	0.31
103.00	0.37	0.39	0.4	0.40	0.31	0.31
98.00	0.36	0.38	0.39	0.39	0.3	0.31
82.50	0.32	0.33	0.33	0.33	0.3	0.30
66.50	0.3	0.30	0.3	0.30	0.3	0.30

Table 3.7.2.3-1-5

MEMBER FORCES
AUXILIARY AND SHIELD BUILDING

AXIAL AND SHEAR FORCES(x10^3 Kips)

			Equivalent static *(Using 100%E ZPAs)*			Time history *(80% E)*			Ratio Equivalent static / Time history		
Elem	Elev	Elev	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear
303	295.23	333.13	2.81	6.22	7.97	2.81	6.53	6.42	1.001	0.952	1.242
301	265	295.23	16.05	15.51	18.74	16.02	16.27	15.47	1.002	0.953	1.211
38	242.5	265	20.36	22.17	25.45	18.60	22.38	21.16	1.095	0.991	1.203
37	220	242.5	22.89	25.84	29.14	20.59	25.51	24.71	1.112	1.013	1.179
36	200	220	25.10	29.01	32.31	22.41	28.04	27.13	1.120	1.035	1.191
35	179.56	200	27.02	31.78	35.14	23.96	30.08	28.66	1.128	1.056	1.226
34	164.51	179.56	28.56	27.00	27.26	25.13	24.65	21.70	1.136	1.095	1.256
33	153.98	164.51	30.70	18.70	28.44	26.97	16.47	22.76	1.138	1.135	1.249
32	145.37	153.98	33.57	14.43	18.92	28.55	12.15	15.26	1.176	1.188	1.240
31	134.87	145.37	35.59	17.28	22.29	30.40	13.91	18.31	1.171	1.242	1.217
13	134.87	179.56	1.55	8.74	12.54	0.00	8.11	10.10		1.077	1.241
10	134.87	164.51	0.00	11.43	2.44	0.00	10.09	1.94		1.132	1.260
8	134.87	153.86	0.00	7.59	13.95	0.00	6.39	11.65		1.187	1.198
7	116.5	134.88	42.21	51.99	59.21	36.10	42.65	47.85	1.169	1.219	1.237
6	106.17	116.5	47.30	60.55	68.16	40.83	47.41	53.69	1.158	1.277	1.269
5	99	106.17	49.54	63.27	71.05	43.02	48.80	55.11	1.151	1.297	1.289
4	91.5	99	53.00	32.84	23.97	46.51	22.53	14.61	1.140	1.457	1.640
3	81.5	91.5	57.51	36.32	27.75	50.80	25.88	16.83	1.132	1.404	1.649
2	66.5	81.5	44.19	21.74	16.63	35.32	15.68	10.27	1.251	1.386	1.619
1	60.5	66.5	119.58	77.12	82.49	77.90	51.35	47.75	1.535	1.502	1.727

Table 3.7.2.3-1-6

MEMBER FORCES
AUXILIARY AND SHIELD BUILDING

MOMENTS (x10^3 Kips feet)

			Equivalent static *(Using 100%E ZPAs)*		Time history *(80% E)*		Ratio Equivalent static / Time history	
Elem	Elev	Elev	about N-S Axis	about E-W Axis	about N-S Axis	about E-W Axis	about N-S Axis	about E-W Axis
303	295.23	333.13	302.10	235.57	266.61	260.99	1.133	0.903
301	265	295.23	868.53	704.41	854.17	872.74	1.017	0.807
38	242.5	265	1441.23	1203.32	1315.66	1374.77	1.095	0.875
37	220	242.5	2096.78	1784.77	1921.62	1989.93	1.091	0.897
36	200	220	2742.99	2365.02	2506.10	2583.91	1.095	0.915
35	179.56	200	3461.27	3014.57	3127.81	3222.60	1.107	0.935
34	164.51	179.56	3870.89	3420.90	3479.65	3608.09	1.112	0.948
33	153.98	164.51	4170.66	3617.62	3723.93	3806.91	1.120	0.950
32	145.37	153.98	4337.07	3745.47	3860.23	4070.55	1.124	0.920
31	134.87	145.37	4573.00	3925.84	3992.65	4257.40	1.145	0.922
13	134.87	179.56	560.22	390.37	451.41	362.38	1.241	1.077
10	134.87	164.51	72.45	338.68	57.41	299.15	1.262	1.132
8	134.87	153.86	264.93	144.06	221.24	121.32	1.197	1.187
7	116.5	134.88	6547.51	5774.79	5428.61	6202.96	1.206	0.931
6	106.17	116.5	7250.37	6392.29	5991.64	6762.95	1.210	0.945
5	99	106.17	7759.36	6843.29	6373.05	7146.70	1.218	0.958
4	91.5	99	7941.96	7079.12	6481.29	7287.50	1.225	0.971
3	81.5	91.5	8217.88	7439.93	6613.75	7499.97	1.243	0.992
2	66.5	81.5	3627.37	4673.08	2474.44	3855.10	1.466	1.212
1	60.5	66.5	4775.48	11391.0	3295.23	9050.29	1.449	1.259

Table 3.7.2.3-1-7

MEMBER FORCES
STEEL CONTAINMENT VESSEL
AXIAL AND SHEAR FORCES($x10^3$ Kips)

			Equivalent static *(Using 100%E ZPAs)*			Time history *(80% E)*			Ratio Equivalent static / Time history		
Elem	Elev	Elev	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear
416	273.83	281.9	0.20	0.23	0.26	0.24	0.27	0.28	0.846	0.848	0.918
415	265.83	273.83	0.48	0.62	0.71	0.60	0.73	0.77	0.798	0.853	0.916
414	255.02	265.83	0.71	1.01	1.15	0.88	1.19	1.25	0.811	0.849	0.918
413	244.21	255.02	0.94	1.41	1.61	1.16	1.66	1.73	0.809	0.849	0.931
412	224	244.21	1.23	1.93	2.23	1.53	2.28	2.36	0.805	0.848	0.944
411	200	224	2.78	4.55	4.88	2.80	4.81	4.23	0.991	0.945	1.154
410	169.93	200	3.25	5.24	5.72	3.36	5.60	5.00	0.968	0.935	1.145
409	162	169.93	3.68	5.82	6.38	3.83	6.19	5.57	0.962	0.941	1.145
408	141.5	162	3.95	6.17	6.76	4.11	6.52	5.89	0.960	0.946	1.147
407	138.58	141.5	4.16	6.42	7.03	4.36	6.76	6.11	0.954	0.949	1.151
406	131.68	138.58	4.18	6.44	7.06	4.36	6.76	6.11	0.959	0.953	1.155
405	112.5	131.68	4.40	6.68	7.34	4.61	6.96	6.30	0.954	0.959	1.165
403	110.5	112.5	4.55	6.84	7.52	4.79	7.07	6.37	0.950	0.968	1.181
402	104.12	110.5	4.57	6.86	7.54	4.79	7.07	6.37	0.954	0.970	1.184
401	100	104.12	4.63	6.93	7.61	4.86	7.10	6.40	0.953	0.975	1.189

MOMENTS ($x10^3$ Kips feet)

			Equivalent static *(Using 100%E ZPAs)*		Time history *(80% E)*		Ratio Equivalent static / Time history	
Elem	Elev	Elev	about N-S Axis	about E-W Axis	about N-S Axis	about E-W Axis	about N-S Axis	about E-W Axis
416	273.83	281.9	2.075	1.845	2.29	2.16	0.906	0.854
415	265.83	273.83	7.711	6.83	10.26	9.54	0.752	0.716
414	255.02	265.83	20.121	17.755	26.95	25.1	0.747	0.707
413	244.21	255.02	37.545	33.005	50.45	47.1	0.744	0.701
412	224	244.21	82.568	72.08	105.31	99.26	0.784	0.726
411	200	224	214.404	199.186	215.37	249.37	0.996	0.799
410	169.93	200	386.513	356.572	365.53	427.69	1.057	0.834
409	162	169.93	437.078	402.717	416.28	485.37	1.050	0.830
408	141.5	162	575.587	529.175	541.12	624.26	1.064	0.848
407	138.58	141.5	596.103	547.898	561.81	647.61	1.061	0.846
406	131.68	138.58	644.856	592.353	604.02	694.26	1.068	0.853
405	112.5	131.68	785.593	720.385	727.75	831.63	1.079	0.866
403	110.5	112.5	800.639	734.061	741.5	848.17	1.080	0.865
402	104.12	110.5	848.726	777.793	782.14	893.22	1.085	0.871
401	100	104.12	880.124	806.36	808.94	923.25	1.088	0.873

Table 3.7.2.3-1-8

MEMBER FORCES
CONTAINMENT INTERNAL STRUCTURES

AXIAL AND SHEAR FORCES($x10^3$ Kips)

			Equivalent static *(Using 100%E ZPAs)*			Time history *(80% E)*			Ratio Equivalent static / Time history		
Elem	Elev	Elev	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear	Axial	N-S Shear	E-W Shear
555	163.79	169	0.01	0.45	0.49	0.01	0.39	0.52	0.900	1.164	0.942
508	153	163.79	0.15	0.63	0.66	0.14	0.55	0.72	1.036	1.145	0.918
507	134.25	153	0.59	1.47	2.92	0.52	1.20	2.13	1.129	1.226	1.369
506	134.25	153	0.21	0.61	2.21	0.15	0.68	2.32	1.400	0.891	0.952
554	121.5	134.25	2.00	11.35	10.21	0.00	7.43	7.19		1.527	1.419
505	107.17	121.5	3.38	11.35	10.21	3.26	7.43	7.19	1.036	1.527	1.419
590	106.32	107.17	0.66	17.63	14.66	0.42	11.19	9.74	1.567	1.575	1.505
504	103	106.32	5.96	17.64	14.66	6.69	11.20	9.74	0.891	1.575	1.505
553	99	103	1.00	19.38	16.57	0.00	12.92	11.23		1.500	1.476
503	98	99	8.78	53.76	67.98	10.52	38.11	49.81	0.835	1.411	1.365
502	82.5	98	19.78	69.81	85.27	19.59	44.71	55.11	1.010	1.561	1.547
501	66.5	82.5	83.01	98.94	111.52	68.58	69.93	69.29	1.210	1.415	1.609

MOMENTS ($x10^3$ Kips feet)

			Equivalent static *(Using 100%E ZPAs)*		Time history *(80% E)*		Ratio Equivalent static / Time history	
Elem	Elev	Elev	about N-S Axis	about E-W Axis	about N-S Axis	about E-W Axis	about N-S Axis	about E-W Axis
555	163.79	169	2.56	2.34	3.22	2.55	0.793	0.919
508	153	163.79	9.65	9.10	10.91	8.45	0.885	1.077
507	134.25	153	69.39	36.81	54.83	32.80	1.265	1.122
506	134.25	153	47.78	11.37	50.97	14.03	0.937	0.810
554	121.5	134.25	248.46	193.72	183.55	139.00	1.354	1.394
505	107.17	121.5	394.26	355.88	286.60	236.34	1.376	1.506
590	106.32	107.17	432.79	373.39	379.00	256.13	1.142	1.458
504	103	106.32	474.10	431.61	407.28	293.30	1.164	1.472
553	99	103	523.77	507.35	367.88	341.48	1.424	1.486
503	98	99	591.75	561.09	395.94	375.75	1.495	1.493
502	82.5	98	2817.12	2473.33	1780.56	1610.91	1.582	1.535
501	66.5	82.5	8789.52	6960.01	5946.55	5621.72	1.478	1.238

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **3.8.4.2-1**

Original RAI Number(s): None (April 3, 2003, meeting summary)

Summary of Issue:

During the April 2 through 5, 2003, design audit, the staff reviewed the applicant's approach to the design of boundary elements potentially needed to reinforce boundaries and edges around openings of structural walls. In accordance with Chapter 21.6 of ACI 349-01, if the vertical compressive stress at the opening does not exceed 0.2 f'_c, then a boundary element is not required. The applicant contended that this compressive stress limit is not applicable when seismic member forces are based on elastic analysis, no ductility reduction factor is applied, and a stress limit of 1.0 f'_c is used as the stress threshold for boundary elements. The staff disagreed with the approach proposed by the applicant, and also pointed out that the stress prediction at an opening is highly dependent on the finite element mesh refinement. In addition, the staff review of Westinghouse calculation APP-1200-CCC-102 "Auxiliary Building Wall 7.3 Reinforcement Calculation" indicated that boundary element evaluations were not considered at the intersection of reinforced concrete walls. The staff position is that the need for boundary elements around openings and at intersections of reinforced concrete walls should be evaluated in accordance with Chapter 21.6 of ACI-349-01. The applicant agreed to consider the staff's positions and to develop criteria to implement the provisions of Chapter 21.6 of ACI-349-01. The applicant's action will be reviewed by the staff when submitted. This is Open Item 3.8.4.2-1.

Westinghouse Response:

During the April 2 through 5, 2003 meeting, Westinghouse presented the stress results shown in Figures 3.8.4.2-1-1 and 3.8.4.2-1-2 in the cylindrical wall of the shield building. These show vertical stresses in the wall due to dead load plus safe shutdown earthquake (SSE). The SSE stresses are combined by the square root sum of the squares (SRSS) method so all stresses are compression. The second figure is an enlarged portion of the first figure in the vicinity of the openings for the equipment hatches and the personnel airlocks. Stresses are shown as the ratio of f'_c. Maximum stresses are up to 0.35 f'_c at low elevations on the west side and up to 0.25 f'_c at low elevations on the east edge. There are higher stresses due to stress concentrations close to the openings.

Westinghouse calculation APP-1200-CCC-102 "Auxiliary Building Wall 7.3 Reinforcement Calculation" reviewed by NRC staff during the audit included boundary element evaluations adjacent to the openings in the wall. It did not document the evaluation of the ends of the wall as boundary elements. At one end the wall frames into the exterior wall on Line I. Vertical stresses at this end are less than 0.2 f'_c. At the other end it frames into the shield building cylinder and vertical stresses exceed 0.2 f'_c as described above. The compressive stresses at the shield building are due to the overturning moment on the shield building with seismic loads towards the east. Wall 7.3 acts as a buttress to the shield building and sees vertical compression for this case. The requirement in the code for boundary elements is applicable to a single wall and is

based on the assumption that the boundary element may have to carry all compressive forces at the critical section at the time when maximum lateral forces are acting on the structural wall. This is not the case for the nuclear island since loads can redistribute to other portions of the structure. The shear resistance from wall 7.3 is much smaller than that from the shield building cylinder. The boundary region at the west end of Wall 7.3 is loaded as part of the shield building and should be evaluated as part of the shield building and not in the calculation for wall 7.3.

The shield building cylinder is a 3 foot thick 142 feet diameter continuous wall extending from elevation 82' 6" to 265' 0". Under seismic loads there is compression at one edge and tension at the opposite edge. There are no free boundaries (except at openings as discussed later). The compressive loads are carried by a large portion of the circumference of the circle; this is a much greater compressive area than the end of the single wall considered in the code. Lateral restraint is provided to the vertical reinforcement due to wall curvature by hoop compressive forces in the concrete or by the hoop reinforcement acting in tension.

Openings in the wall are small relative to the full height and circumference of the wall. The behavior of the wall in the vicinity of openings does not affect the global behavior. At openings in the wall, hooks on horizontal reinforcement or separate U stirrups are provided engaging the vertical reinforcement. For closely spaced openings, these horizontal bars or U-stirrups results in reinforcement similar to a column.

Design of the columns between the air inlet openings is described in DCD subsection 3H.5.6.2. The maximum concrete compressive stress due to dead loads and live loads plus SSE combined by the 1.0, 0.4, 0.4 method is 0.25 f'_c. The reinforcement provided is summarized in sheet 2 of Table 3H.5-9 and is shown in sheets 4 and 5 of Figure 3H.5-11.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

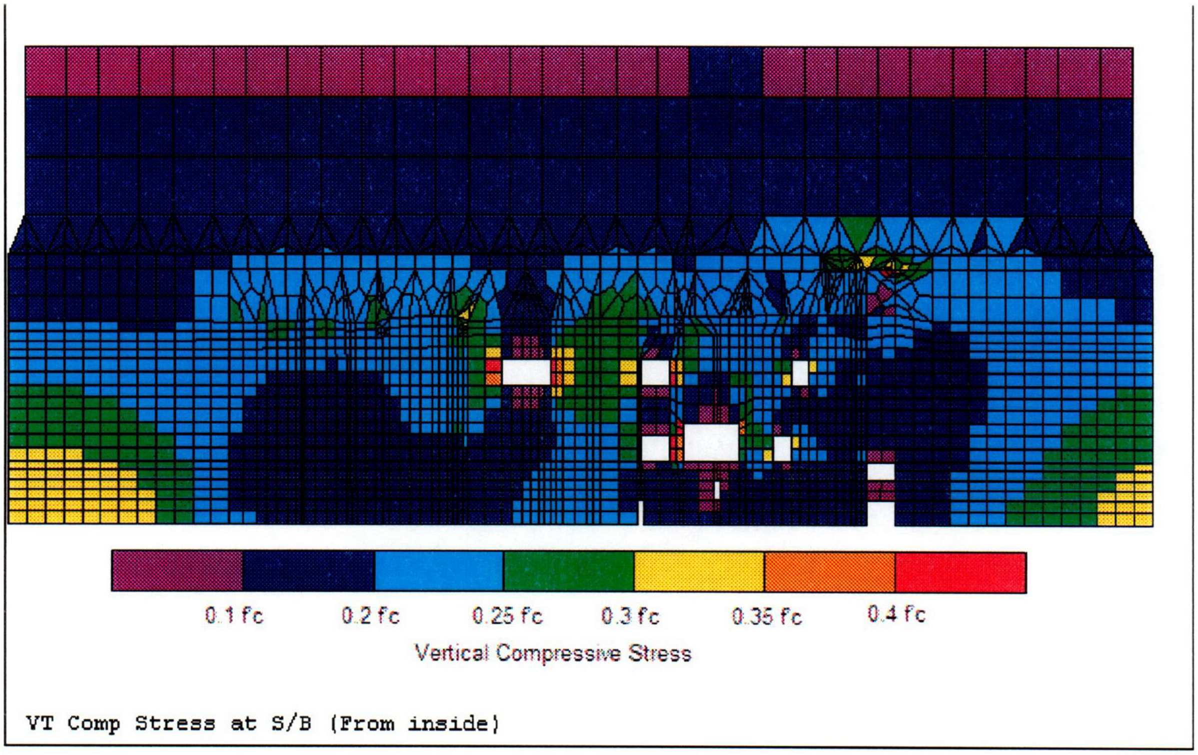


Figure 3.8.4.2-1-1
AP1000 Shield Building
Vertical stresses due to DL + SSE (SRSS)

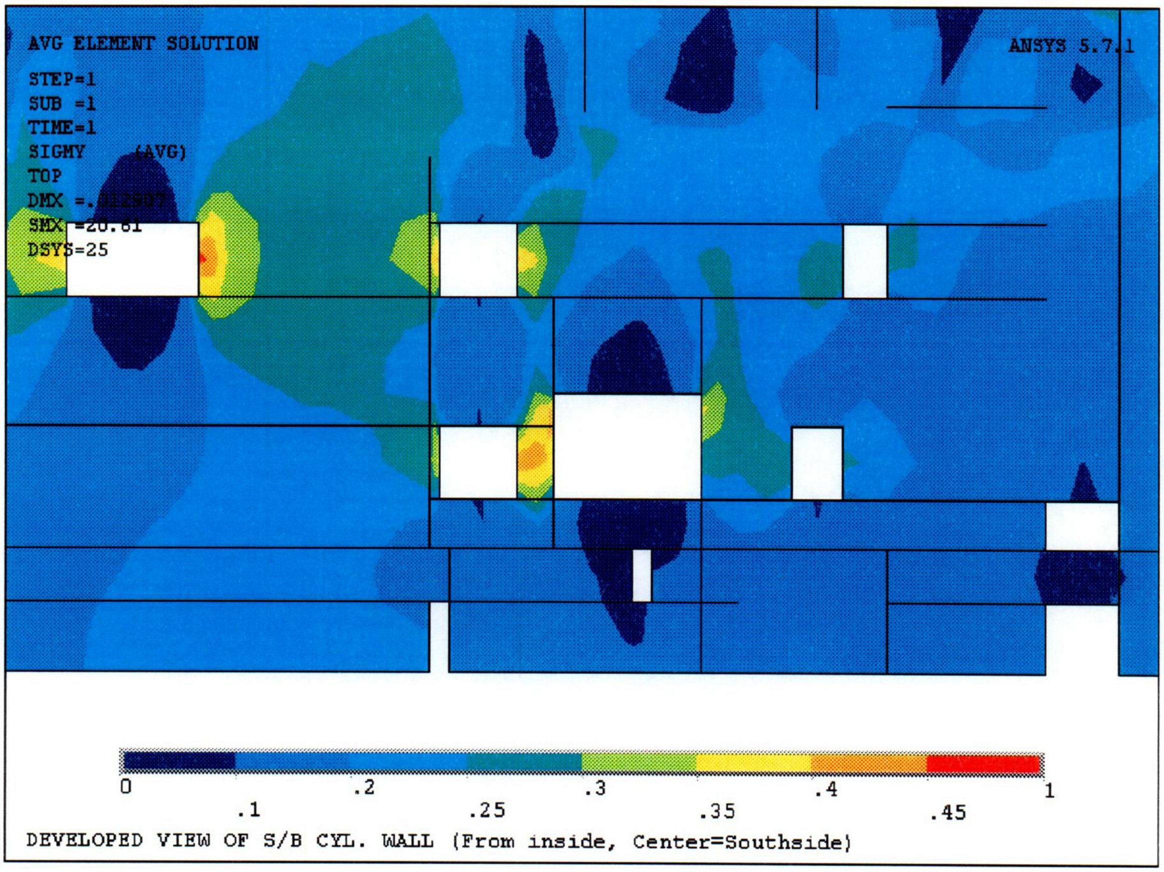


Figure 3.8.4.2-1-2
AP1000 Shield Building in Vicinity of Openings
Vertical stresses due to DL + SSE (SRSS)

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 10.2.8-2

Original RAI Number(s): 251.025, 251.026, 251.027

Summary of Issue:

In DCD Tier 2 Section 10.2.3.2, "Fracture Toughness," Westinghouse discusses, in general terms, the maximum initial flaw size and crack growth rates. The staff evaluation of the application of non-destructive examination (NDE), initial flaw size, and crack growth rates, in terms of addressing the probability aspects of turbine missile generation, is discussed in Section 3.5.1.3 of this report. To ensure that the maximum applied stress intensity factor for rotors at various speed was derived appropriately, the NRC staff reviewed DCD Tier 2 Section 10.2.3.2.1, "Brittle Fracture Analysis," and requested additional information in RAIs 251.025, 251.026, and 251.027, for resolving certain concerns about this analysis.

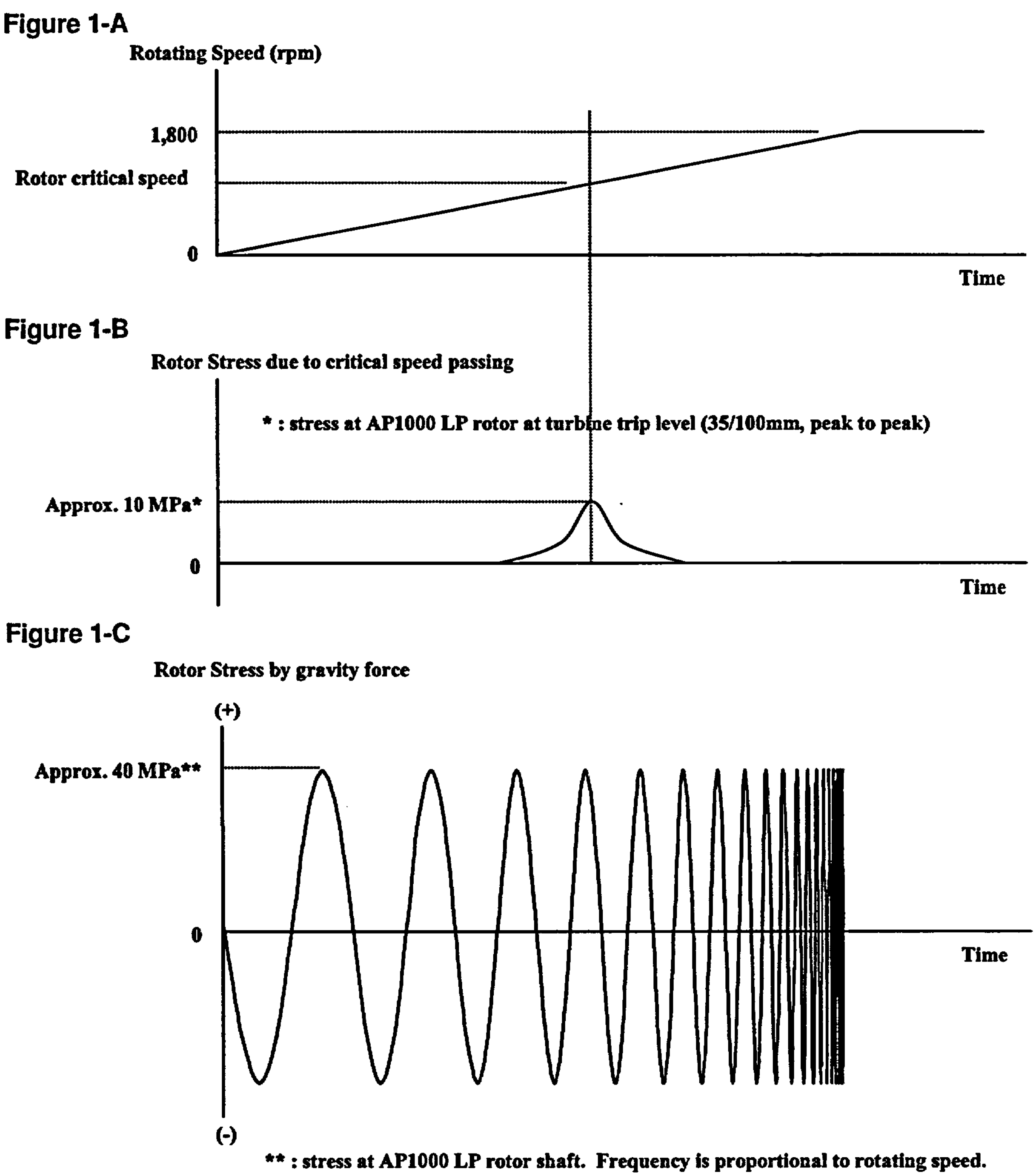
DCD Tier 2 Section 10.2.3.2.1 described a brittle fracture analysis considering the design duty cycle stresses, number of cycles, ultrasonic examination capability and growth rate of potential flaws. In its response to RAI 251.025 regarding the conservative factors of safety that were included in estimating the above-mentioned parameters, Westinghouse referred to the low cycle fatigue (LCF) crack analysis of WCAP-15783. (WCAP-15783 is used to support the NRC staff's review of turbine missiles in DCD Tier 2 Section 3.5.1.3, as well as to support the turbine rotor integrity of DCD Tier 2 Section 10.2.3.) The brittle fracture analysis described in Section 10.2.3.2.1 is completely contained in WCAP-15783. The staff considers this response appropriate because it is clear that the operational stresses in the shaft are much lower than the operational stresses in the disks, making the disks more limiting than the shaft. Hence, the WCAP-15783 analyses for disks are sufficient for assessing overall rotor integrity.

In the revised WCAP-15783, Westinghouse replaced an unreasonable KIc value used in the LCF analysis, as identified in RAI 251.025, by a reasonable proprietary value. In its response to RAI 251.026 dated March 25, 2003, regarding the vibratory stresses, Westinghouse referred to WCAP-15783 and stated that "(t)he vibratory stress when passing through critical speeds during startups and shutdowns is not included in the evaluation of low cycle fatigue. This is because the bending stress for this condition is greatest on the surface of the rotor and negligibly small on the rotor bore surface, which is the point where maximum stress of low cycle fatigue appears." The NRC staff considers this to be appropriate because the vibratory stress occurred at a different location, not the place where LCF effect is evaluated. However, the response has not provided adequate justification to conclude that rotor resonant stresses resulting from passing through rotor critical speeds are insignificant. This is DSER Open Item 10.2.8-2.

Westinghouse Response:

Please refer to the attached Figure 1 for the following discussion.

Figure-1: Schematic of Rotor Stress During Start-up



Rotor resonant stress is not an alternating stress, but is a static stress. As the turbine speed increases from rest passing through resonance (See Figure 1-A), the maximum turbine trip displacement is 35/100 mm, peak to peak with a force amplitude of approximately 10 MPa. (See Figure 1-B).

The rotor stress developed by gravity force or by possible misalignment of the bearings is evaluated in section 4.2 of WCAP-15783 and is a high cycle alternating stress and the stress behavior is schematically shown in Figure 1-C.

As the resonant stress is infrequent (estimated to be less than 10^3 cycles based on the number of starts and stops), it is not appropriate to consider it during the high cycle fatigue analysis.

Although the rotor stress at critical speed is infrequent, it could be considered in the low cycle fatigue analysis. However, the stress level in rotor due to the rotor passing through critical speed is less than the endurance limit of the rotor material and there is no life consumption due to the infrequency of this stress. Therefore, the rotor resonant stresses resulting from passing through rotor critical speeds are not significant.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **14.2-1**

Original RAI Number(s): **None**

Summary of Issue:

The review documented in Section 14.2 of this chapter reflects the staff assessment of the Initial Test Program. While the staff has completed its review of whether the Initial Test Program conforms to specified Regulatory Guides and certain other matters, as discussed below, the staff has not completed its review of certain aspects of the testing scope, general test methods, and acceptance criteria. Specifically, the staff has not completed its review of whether the initial test program adequately demonstrates the performance of structures, systems, or components important to safety, in accordance with the guidance in Standard Review Plan (SRP) 14.2. It should be noted that the results of this review might affect the staff's conclusions set forth in this section. Pending completion of the review, this is Open Item 14.2-1.

Westinghouse Response:

The AP1000 Initial Test Program is the same as the AP600 Initial Test Program. The AP600 Initial Test Program was found to be in accordance with the applicable guidance in the Standard Review Plan 14.2 as part of the AP600 Design Certification review that was documented in the AP600 Final Safety Evaluation report (NUREG-1512) issued in September 1998. Therefore Westinghouse believes the AP1000 Initial test Program is in accordance with the applicable portions of SRP 14.2.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 17.3.2-3

Original RAI Number(s): 260.007

Summary of Issue:

Exception to RG 1.28: As noted previously in this chapter, in DCD Tier 2 Section 1, Appendix 1A, the applicant took exception to record retention recommendations in RG 1.28. Specifically, RG 1.28, Regulatory Position C.2, Quality Assurance Records, states, in part, that programmatic nonpermanent records should be retained for at least 3 years. For programmatic nonpermanent records, the retention period should be considered to begin upon completion of the activity. In addition, RG 1.28 states that product and programmatic nonpermanent records should be retained at least until the date of issuance of the full power operating license of the unit. Under 10 CFR Part 52, issuance of a COL is comparable to issuance of a full power operating license under 10 CFR Part 50. The applicant stated that because a definitive schedule for obtaining a full power operating license does not exist, the records retention plan is keyed to the final design approval. The applicant stated that a 3 year programmatic records retention period will be initiated starting on the date that NRC issues an AP1000 final design approval. The NRC staff determined that this exception to RG 1.28 may not be acceptable since programmatic nonpermanent records could be discarded 3 years after issuance of a final design approval; therefore, these records may not be available to a future COL applicant. The NRC staff requested additional information to assess the basis for not retaining nonpermanent records until a COL is issued. The applicant should provide a list of the specific records types that they are proposing to discard after 3 years. The applicant should also provide additional justification for discarding each of these record types after final design approval. This information was requested from the applicant through RAI 260.007. This is DSER Open Item 17.3.2-3.

Westinghouse Response:

This question was originally identified as RAI OI-260.007 Rev. 0. Westinghouse provided a response to RAI OI-260.007 Rev. 0, which was originally transmitted to the NRC via DCP/NRC1588 dated 05/13/03.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **17.3.2-4**

Original RAI Number(s): **261.008**

Summary of Issue:

The NRC staff also noted that in DCD Tier 2 Section 17.6, "References," The applicant did not reference the following documents discussed in DCD Tier 2 Section 17.3:

> Westinghouse Electric Company Quality Management System (QMS), Revision 5, dated October 1, 2002.
>
> WCAP-15985, "AP1000 Implementation of the Regulatory Treatment of Nonsafety-Related Systems Process," Revision 1, dated April 2003

Westinghouse should add these references to DCD Tier 2 Section 17.6. In addition, there is no reference to a project specific quality plan for the AP1000 design similar to Reference 4, WCAP-12600, "AP600 Advanced Light Water Reactor Design Quality Assurance Program Plan," Revision 4 dated January 1998. This information was requested from Westinghouse in RAI 261.008. This is DSER Open Item 17.3.2-4.

Westinghouse Response:

This question was originally identified as RAI OI-260.008 Rev. 0. Westinghouse provided a response to RAI OI-260.008 Rev. 0, which was originally transmitted to the NRC via DCP/NRC1588 dated 05/13/03.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19.1.10.2-6

Original RAI Number(s): 720.038

Summary of Issue:

Shutdown Fire Risk Evaluation

The applicant submitted the AP1000 shutdown fire risk evaluation on 3/28/03. The AP1000 fire risk analysis has a different grouping of fire areas and different combustible loadings than the AP600 shutdown fire risk evaluation, Therefore, the adequacy of the AP1000 shutdown fire risk evaluation is still being reviewed by the staff. This is Open Item 19.1.10.2-5,

Westinghouse Response:

Westinghouse believes that the AP1000 shutdown fire risk evaluation provided in the PRA Chapter 57 Fire Risk Assessment revision 3 issued on 05/16/03 is adequate.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19.3.3-1

Original RAI Number(s): 440.110

Summary of Issue:

The applicant provided the following information for the design features that reduce risks associated with temporary RCS boundaries for the AP1000:

> Reduced reliance on freeze seals
>
> Freeze seals are used for repairing and replacing components such as valves, pipe fittings, pipe stops and pipe connections when it is impossible to isolate the area of repair any other way. Industrial experience indicates that some freeze seals have failed in nuclear power plants and resulted in significant events. In addressing the issue of freeze seals failure, the AP1000 design reduces the potential applications of freeze seals by reducing the number of lines that connect to the RCS and by providing the ability to perform inservice tests (ISTs) on many valves that connect to the RCS pressure boundary. The IST program reduces the requirements for disassembling RCS pressure boundary valves to perform operability tests. The use of freeze seals during a forced outage typically occurs in cold shutdown (Mode 5). During Mode 5, the PXS is required by the TSs (DCD Tier 2 Chapter 16, Table B 3.0-1) to be available, and therefore, the PXS can respond to a loss of coolant through a failed freeze seal.

The staff finds that the reduction of RCS penetrations, the ability to perform ISTs, the use of fixed incore system, and higher nozzle dam design pressure will reduce the risks associated with the loss of temporary RCS boundaries. Therefore, the staff concludes that the design relative to temporary RCS boundaries is acceptable.

DCD Tier 2 Section 13.5, "Plant Procedures," contains COL information items requiring plant procedures to be prepared for each plant. However, the COL applicant should develop plant specific guidelines that would reduce the potential for loss of RCS boundary and inventory when using freeze seals. This COL information is not specified in the DCD. Therefore, this is Open Item 19.3.3-1 and COL Action Item 19.3.3-1.

Westinghouse Response:

This requirement will be added to DCD Section 13.5.

Design Control Document (DCD) Revision:

Revise section 13.5.

From DCD pages 13.3 and 13.4. (Note that the markup also includes changes per Open Item 19.3.7-1):

13.5 Plant Procedures

Plant procedures are the responsibility of the Combined License applicant. References to applicable combined license information are included in Section 1.8. This includes, for example, reference to guidelines on inservice inspection in Chapters 3 and 6, and initial testing in Chapter 14. Operational experience and the resolution of generic issues to be considered in the preparation of plant procedures is outlined in Section 1.9.

Reference 1 provides input to the Combined License applicant for the development of plant operating procedures, including information on the development and design of the AP600 emergency response guidelines and emergency operating procedures. Also included in Reference 1 is information on the computerized procedure system, which is the human system interface that allows the operators to execute the plant procedures. From an operational viewpoint, in particular with regards to plant procedures, the AP1000 is the same as the AP600. This allows the use of a common guide such as Reference 1.

The computerized procedure system is not part of the AP1000 design scope that the Nuclear Regulatory Commission is being asked to approve. The acceptability of the computerized procedure system, and its backup, for application to the AP1000 design will be determined during the implementation of the AP1000 verification and validation program (see DCD Section 18.8) and reviewed as part of an application for a combined license.

The Combined License applicant is responsible for the development of plant specific refueling plans (DCD Appendix 19E provides input for refueling plans).

Outage plans, which are the responsibility of the Combined License applicant, should as a minimum address the following elements:

- **An outage philosophy which includes safety as a primary consideration in outage planning and implementation,**
- **Separate organizations responsible for scheduling and overseeing the outage; provisions for an independent safety review team that would be assigned to perform final review and grant approval for outage activities,**
- **Control procedures which address both the initial outage plan and all safety-significant changes to schedule,**
- **Provisions to ensure that all activities receive adequate resources,**
- **Provisions to ensure defense-in-depth during shutdown and ensure that margins are not reduced; an alternate or backup system must be available if a safety system or a defense-in-depth system is removed from service, and**
- **Provisions to ensure that all personnel involved in outage activities are adequately trained; this should include operator simulator training to the extent practicable; other plant personnel, including temporary personnel, should receive training commensurate with the outage tasks they will be performing.**

If freeze seals are to be used, the Combined License applicant must develop plant specific guidelines to reduce the potential for loss of RCS boundary and inventory when they are in use.

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19.3.7-1

Original RAI Number(s): None

Summary of Issue:

The staff will review the COL applicants' outage planning and control program, and the COL applicants will have to appropriately address the factors that improve low-power and shutdown operations. As a minimum, these factors will include the following important elements:

- an outage philosophy which includes safety as a primary consideration in outage planning and implementation,
- separate organizations responsible for scheduling and overseeing the outage; provisions for an independent safety review team that would be assigned to perform final review and grant approval for outage activities,
- control procedures which address both the initial outage plan and all safety-significant changes to schedule,
- provisions to ensure that all activities receive adequate resources,
- provisions to ensure defense-in-depth during shutdown and ensure that margins are not reduced; an alternate or backup system must be available if a safety system or a defense-in-depth system is removed from service, and
- provisions to ensure that all personnel involved in outage activities are adequately trained; this should include operator simulator training to the extent practicable; other plant personnel, including temporary personnel, should receive training commensurate with the outage tasks they will be performing.

This COL information is not specified in the DCD. Therefore, this is Open Item 19.3.7-1 and COL Action Item 19.3.7-2.

Westinghouse Response:

These guidelines will be incorporated into the DCD.

Design Control Document (DCD) Revision:

Revise section 13.5.

From DCD pages 13.3 and 13.4. (Note that the markup also includes changes per Open Item 19.3.3-1):

13.5 Plant Procedures

Plant procedures are the responsibility of the Combined License applicant. References to applicable combined license information are included in Section 1.8. This includes, for example, reference to guidelines on inservice inspection in Chapters 3 and 6, and initial testing in Chapter 14. Operational experience and the resolution of generic issues to be considered in the preparation of plant procedures is outlined in Section 1.9.

Reference 1 provides input to the Combined License applicant for the development of plant operating procedures, including information on the development and design of the AP600 emergency response guidelines and emergency operating procedures. Also included in Reference 1 is information on the computerized procedure system, which is the human system interface that allows the operators to execute the plant procedures. From an operational viewpoint, in particular with regards to plant procedures, the AP1000 is the same as the AP600. This allows the use of a common guide such as Reference 1.

The computerized procedure system is not part of the AP1000 design scope that the Nuclear Regulatory Commission is being asked to approve. The acceptability of the computerized procedure system, and its backup, for application to the AP1000 design will be determined during the implementation of the AP1000 verification and validation program (see DCD Section 18.8) and reviewed as part of an application for a combined license.

The Combined License applicant is responsible for the development of plant specific refueling plans (DCD Appendix 19E provides input for refueling plans).

Outage plans, which are the responsibility of the Combined License applicant, should as a minimum address the following elements:

- **An outage philosophy which includes safety as a primary consideration in outage planning and implementation,**
- **Separate organizations responsible for scheduling and overseeing the outage; provisions for an independent safety review team that would be assigned to perform final review and grant approval for outage activities,**
- **Control procedures which address both the initial outage plan and all safety-significant changes to schedule,**
- **Provisions to ensure that all activities receive adequate resources,**
- **Provisions to ensure defense-in-depth during shutdown and ensure that margins are not reduced; an alternate or backup system must be available if a safety system or a defense-in-depth system is removed from service, and**
- **Provisions to ensure that all personnel involved in outage activities are adequately trained; this should include operator simulator training to the extent practicable; other plant personnel, including temporary personnel, should receive training commensurate with the outage tasks they will be performing.**

If freeze seals are to be used, the Combined License applicant must develop plant specific guidelines to reduce the potential for loss of RCS boundary and inventory when they are in use.

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19A.2-1

Original RAI Number(s): None

Summary of Issue:

<u>Deterministic Strength Factor</u>

The deterministic design process involves the use of: (1) actual stress that is less than the allowable value specified in the design code, and (2) the margin used in the code allowable values by the code or standard developing body. The applicant has not explained how this factor was used in its probabilistic fragility analysis. This is Open Item 19A.2-1.

Westinghouse Response:

Deterministic strength factors are defined by a margin factor based on the failure that is being evaluated for the structural element being analyzed. These margin factors are established based on the controlling load combination, associated allowables, margin of actual stress to code allowable, and the factor of safety related with the code allowable. The same margin factors are used for the AP1000 plant as employed for the AP600 plant. The NRC, as part of the AP600 licensing process, reviewed these margin factors. The deterministic margin factors (X_i) are used in the formula given in Probabilistic Fragility Analysis item of AP1000 PRA section 55.2.2.3, Analysis of Structure Response that defines the mean peak seismic ground capacity. This is also discussed in AP600 FSER 19A.2-1

The mean peak seismic ground capacity, A_m, is related to the stress and strength design margin factors by the following expression:

$$A_m = (\Pi_i [X_i])A_o$$

where,

A_m	=	Mean peak seismic ground capacity
X_i	=	ith design mean margin factor
Π_i	=	Product notation
A_o	=	Nominal seismic peak ground capacity

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: **19A.2-3**

Original RAI Number(s): **None**

Summary of Issue:

<u>Material</u>

The allowable stress values provided in codes and standards are based on minimum specified yield strength in tension or compressive strength in crushing. Consequently, actual material properties that are derived from the yield strength or crushing strength have variability. The applicant has not explained how this factor was used in its probabilistic fragility analysis. This is Open Item 19A.2-3.

Westinghouse Response:

Material strength factors are defined by margin factors and lognormal standard deviations (LSDs). They are used in the formulas given in Probabilistic Fragility Analysis item of AP1000 PRA section 55.2.2.3, Analysis of Structure Response. The same material margin factors and LSDs are used for the AP1000 plant as employed for the AP600 plant. The NRC, as part of the AP600 licensing process, reviewed these material factors and LSDs and found them acceptable (FSER 19A.2.1.2.1).

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19A.2-4

Original RAI Number(s): None

Summary of Issue:

<u>Analysis of Modeling Error</u>

Modeling error stems from a number of sources that include stiffness parameters, modeling of masses due to live load, connectivity between structural members, support conditions, and others. The applicant did not explain how this factor was used in its probabilistic fragility analysis of various structures and equipment. For the modal frequency variation, the applicant used a composite logarithmic standard deviation, βc, of 0.3. The use of a βc value of 0.3 means that modal frequency values can vary by a factor of 1.8. The applicant needs to justify the use of such a high variability factor for the natural frequency calculations when using detailed finite element models. This is Open Item 19A.2-4.

Westinghouse Response:

As stated in AP1000 PRA Chapter 55, modeling errors are related to: Mode Shapes; Modal Frequency Variability; and Imperfections. The fragility data for the modeling errors are defined by margin factors and lognormal standard deviations (LSDs). They are used in the formulas given in Probabilistic Fragility Analysis item of AP1000 PRA section 55.2.2.3, Analysis of Structure Response. This is the same procedure and methodology as used for the AP600 plant. Further, the same modeling error margin factors and LSDs are used for the AP1000 plant as utilized for the AP600 plant. The NRC, as part of the AP600 licensing process, reviewed the methodology and values used for the modeling fragility data and found them acceptable (documented in AP600 FSER 19A.2.1.1.3).

Westinghouse agrees that the modal frequency can vary by a factor of 1.8. The modal frequency variation is based on the recommendations of Reference 19A.3-1-1. It is stated in this reference (Chapter 5, page 144 and 145): "The modal frequency variability shifts the frequency which spectral accelerations are to be determined, ... Based on experience and Hadjian et al., 1977, the coefficient of variation (approximate logarithmic standard deviation) of frequency is estimated to be approximately 0.3." This variability factor was reviewed by the NRC and documented as acceptable in FSER 19A.2.1.1.3 Modeling, <u>Modal Frequency Variability</u>.

References

19A.3-1-1 Uncertainty and Conservatism in the Seismic Analysis and Design of Nuclear Facilities, Working Group on Quantification of Uncertainties, American Society of Civil Engineers, ISBN 0-87262-547-8, 1986.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19A.2-8

Original RAI Number(s): None

Summary of Issue:

Deterministic Approach

The applicant used the deterministic approach to estimate the HCLPF values of primary system component supports. The components included in the approach are: polar crane, baffle plate supports, heat exchanger for the passive residual heat removal system, core makeup tank and valves. The applicant used lower bound values, and it appears that there was no need for invoking factors of conservatism to arrive at the HCLPF values. It is noted that the core makeup tank has a HCLPF value of 0.54g; therefore, any increase in seismic response of the containment internal structure due to lift off of the internal structure or the nuclear island structure would necessitate a review of this HCLPF value. This is Open Item 19A.2-8.

Westinghouse Response:

The effects of basemat uplift have been evaluated for AP1000 using seismic time history analyses. Peak accelerations, floor response spectra, and member forces from seismic time history analyses that included basemat uplift were compared to seismic time history analyses that did not include lift off. The comparisons show that the basemat uplift effect is insignificant. Results and discussion are given in DSER Open Item Number 3.7.2.3-1.

In order to make conclusions for higher seismic events (> 0.3g), seismic response spectra (@5% equipment damping) were developed for the 0.5g case. Response spectra that include nonlinear liftoff effects were developed at different elevations using the auxiliary shield building (ASB) stick model described in DSER Open Item Number 3.7.2.3-1. The maximum uplift of the basemat is 0.29". In Figures 19A.2-8-1 to 19A.2-8-5 comparisons are made of these response spectra to the seismic response spectra using the linear ASB stick model. As seen from this comparison liftoff is not significant for horizontal response since the horizontal response spectra are similar. In the region of the shield building roof the vertical response spectra are comparable. There are differences in the vertical response spectra in the higher frequency region for the Shield Building cylinder up to elevation 265'. However, the differences shown in these curves will not affect the HCLPF values because:

- High frequency content due to impact is not damaging
- High frequency seismic response is limited to the cylinder portion of the Shield Building
- Side soil effects, not considered in overturning study, will have significant effect on liftoff

These items are discussed in more detail below.

High Frequency Content

High frequency content caused by liftoff is intermittent during the seismic response due to the impact of the NI basemat on the foundation media. This is not a damaging excitation since response is limited and resonance effects are greatly reduced.

High frequency seismic response of the Shield Building cylinder

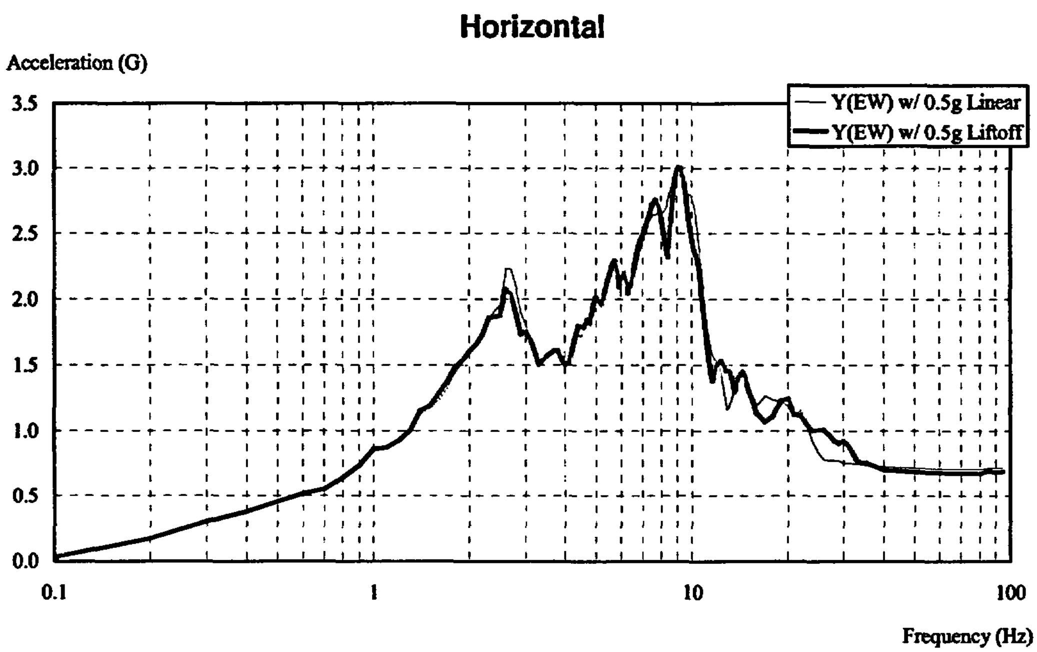
The cylinder portion of the Shield Building high frequency content is amplified. Outside of the Shield Building, this high frequency response will not be as pronounced since the height of the other buildings are significantly reduced, and the mass effect is not as prominent because of the height reduction and there is no water mass at high elevations as there is for the Shield Building because of the PCS tank. The high frequency response will be filtered in the other buildings reducing rigid body motion, similar to the Shield Building roof response, due to such items as lower response frequencies and construction joints that introduce "gaps".

Side Soil Effects

It is noted that these analyses did not include the effect of side soils that can be significant. For the AP600 plant a study of seismic soil pressure distribution on the Nuclear Island structure was made. The effect of side soil on the basemat is a measure of its effect on the seismic response with basemat liftoff. The analyses performed in this study used a uniform subgrade modulus and included liftoff when the soil springs would be in tension. Soil reactions on the underside of the mat and the sidewalls were investigated from a two-dimensional (2D) SASSI analysis of the AP600. The SASSI results indicate that bearing pressures due to seismic loads may be only 54 percent of those calculated neglecting the benefit of the side soil. From the AP600 study of seismic soil pressure distribution it can be concluded that side soil effects, if included in the nonlinear liftoff seismic response study, can reduce (potentially significantly) the vertical seismic response. Using 50%, similar to the reduction in bearing pressure documented from the AP600 study, the vertical seismic response spectra with liftoff will be similar or below the seismic response spectra with no liftoff.

Conclusion

There is no increase in seismic response of the containment internal structure due to lift off that will change the HCLPF values.



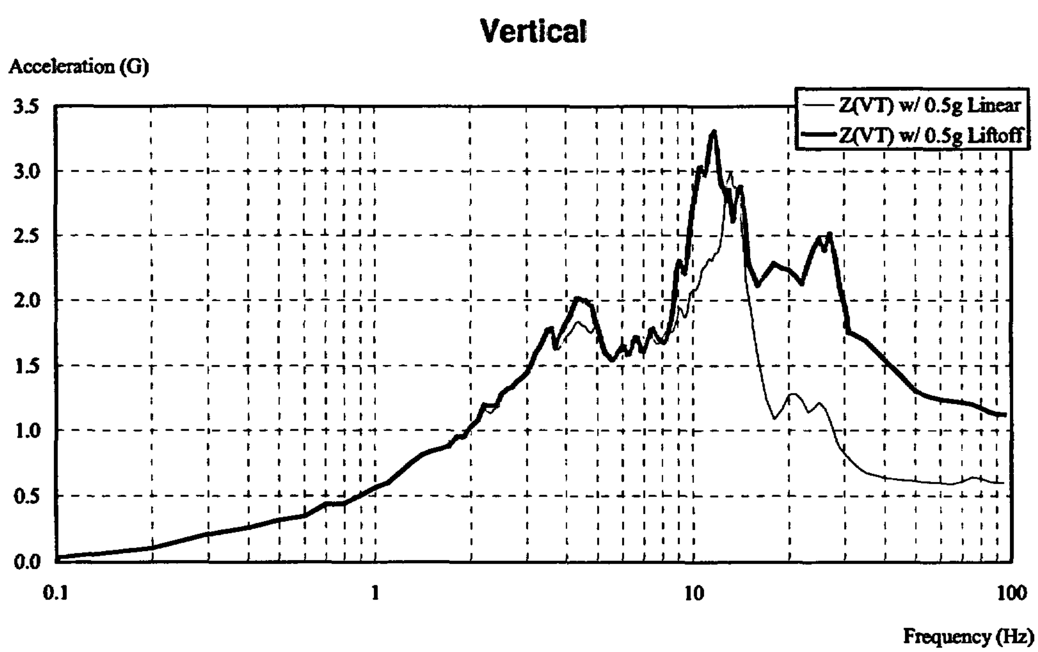
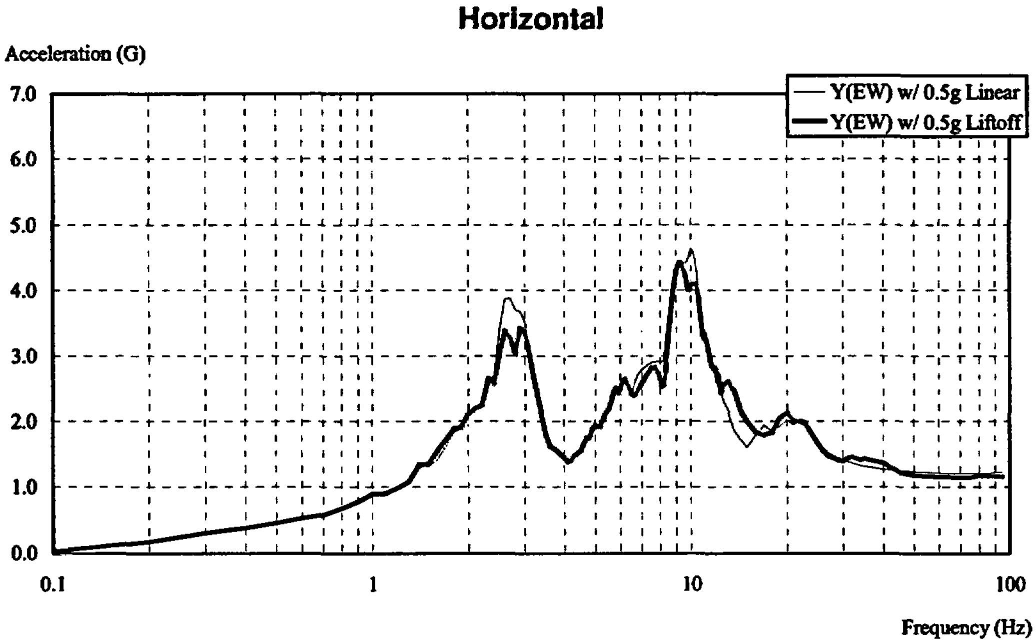


Figure 19A.2-8-1: Floor Response Spectra of ASB Node at EL. 116.50'



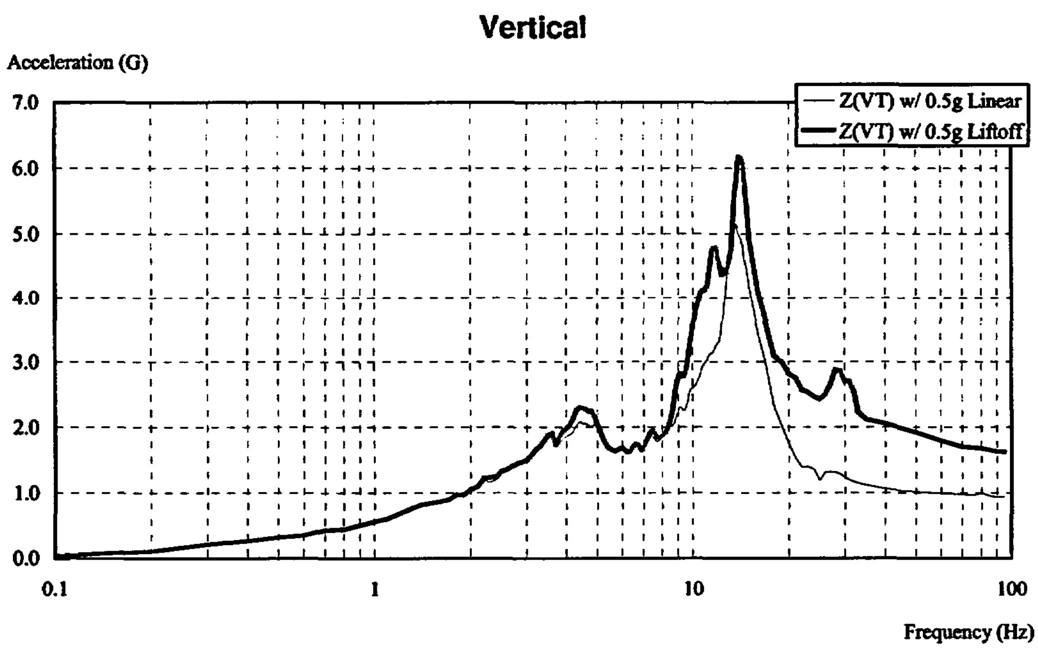
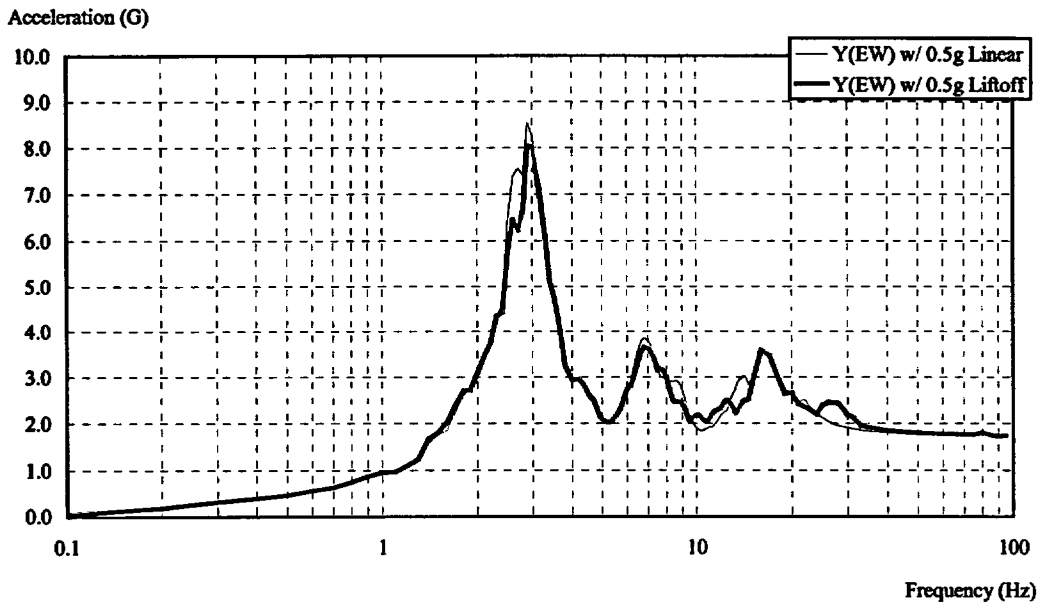


Figure 19A.2-8-2: Floor Response Spectra of ASB Node at EL. 179.56'

Horizontal



Vertical

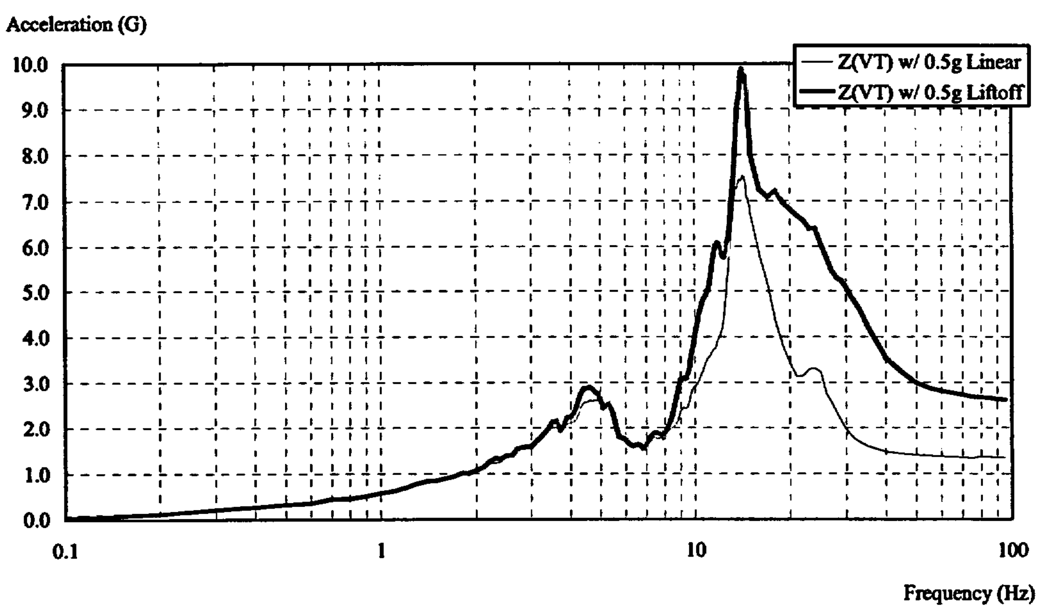
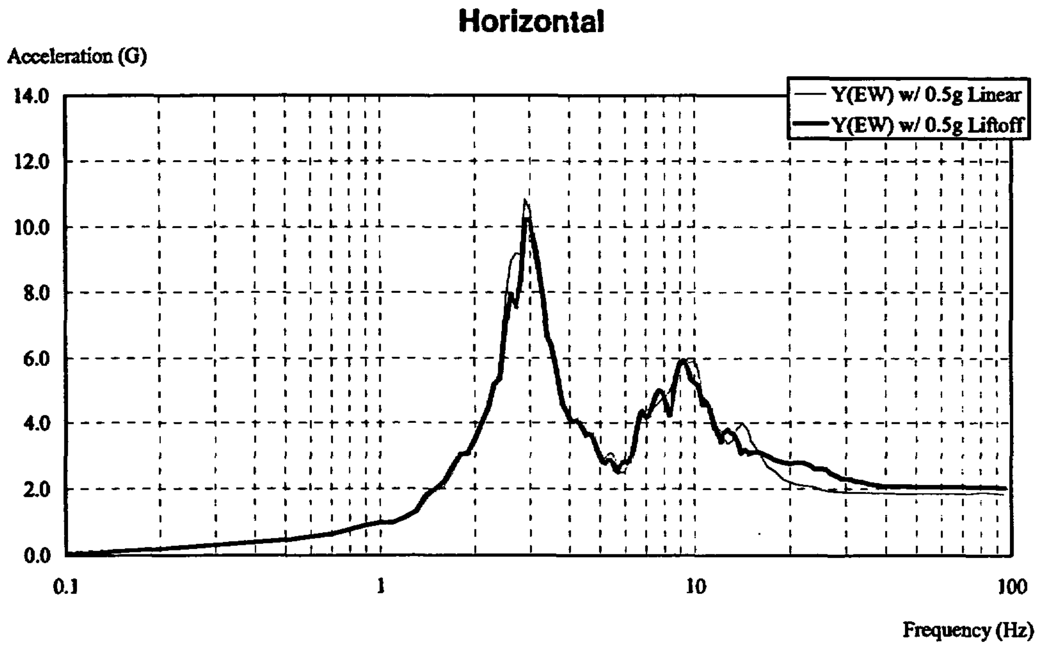


Figure 19A.2-8-3: Floor Response Spectra of ASB Node at EL. 265.00'



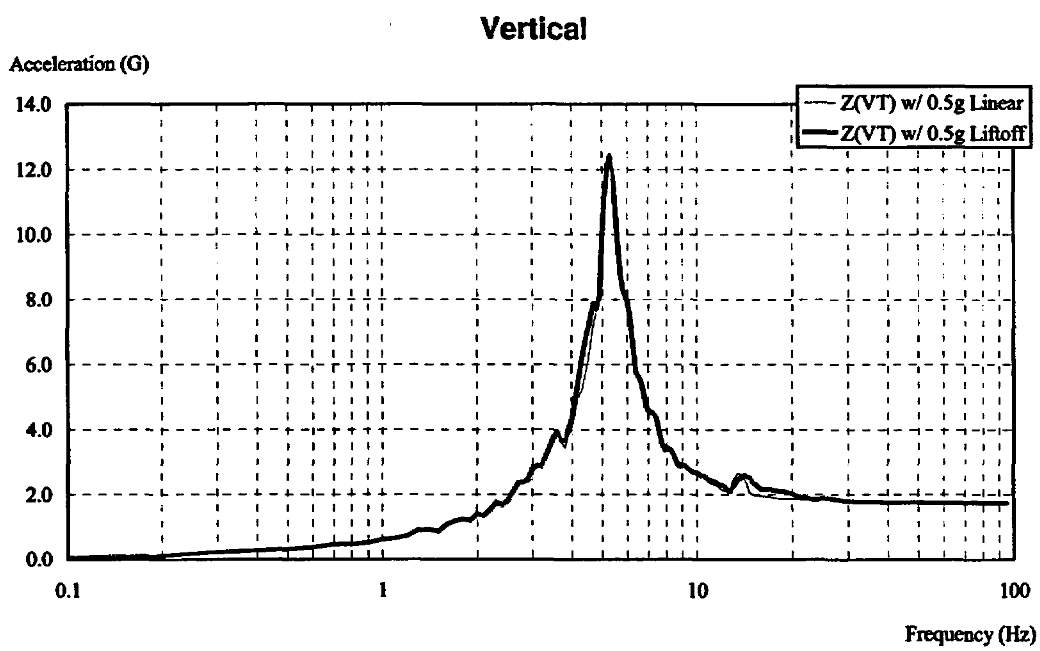
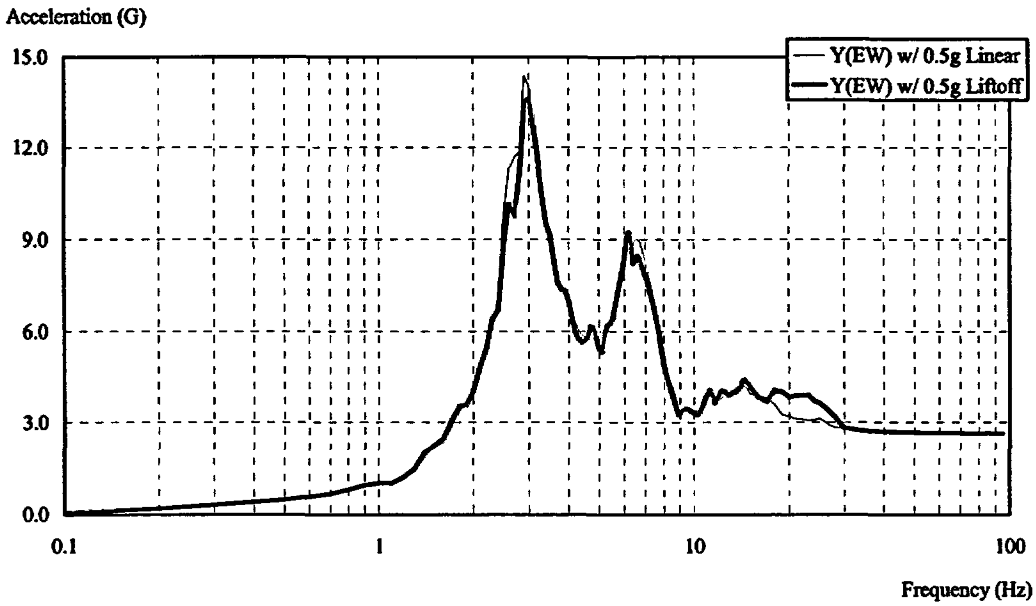


Figure 19A.2-8-4: Floor Response Spectra of ASB Node at EL. 295.23'

Horizontal



Vertical

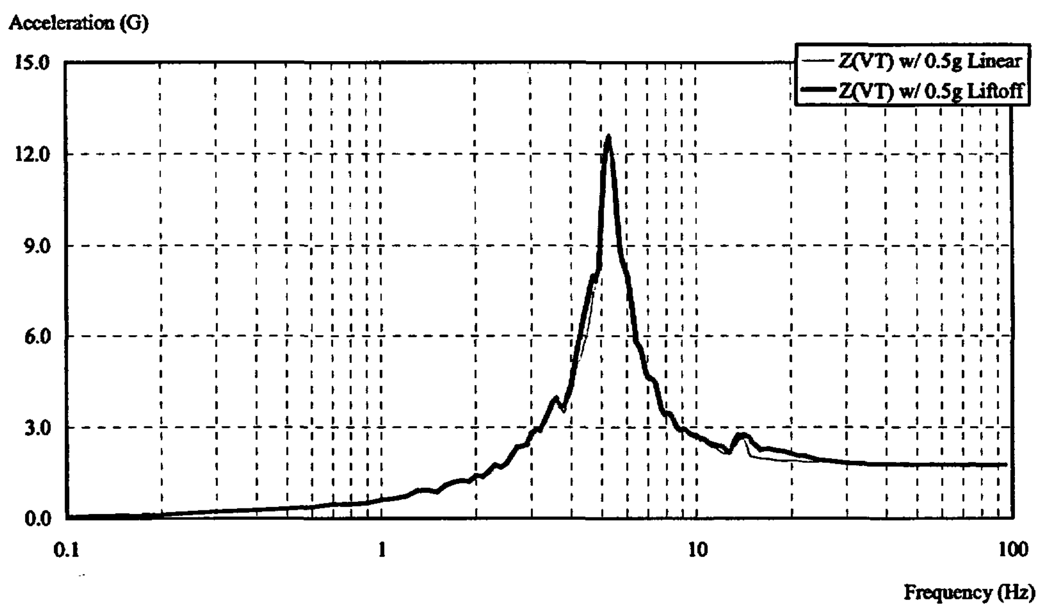


Figure 19A.2-8-5: Floor Response Spectra of ASB Node at EL. 333.13'

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 19A.2-9

Original RAI Number(s): None

Summary of Issue:

Generic Fragility Data

When HCLPF values could not be determined by using one of the methods described above, Westinghouse used generic fragility data. The cases where this approach was used are the following:

- Reactor internals and core assembly that includes fuel
- Control rod drive mechanism (CRDM) and hydraulic drive units
- Reactor coolant pump
- Accumulator tank
- Piping
- Cable trays
- Valves
- Main control room operation and switch stations
- Ceramic insulators
- Battery racks

The generic fragility data came from the Utility Requirements Document which was reviewed by the NRC. Therefore, the use of generic fragility data developed by a joint industry group in the Utility Requirements Document is acceptable. However, the applicant has not indicated what amplification factor, if any, was used to adjust the generic fragility data for the AP1000 configuration. The PCS water flow transmitter, located at Elevation 261' with a HCLPF value of 0.53 g, is likely to have an amplified seismic response. The applicant needs to justify the HCLPF values in the range of 0.53 g and 0.73 g that were obtained from the generic data as shown in the AP1000 PRA Table 55-1, Sheet 3 of 4. This is Open Item 19A.2-9.

Westinghouse Response:

The AP600 methodology used for generic fragility data is also utilized for the AP1000 plant. No amplification factor was used to adjust generic fragility data for the AP1000 plant. These generic fragility data are considered representative of the anticipated capacity. The fragility data is from ALWR URD, Volume III, ALWR Passive Plant, Chapter 1, Appendix A, PRA Key Assumptions and Groundrules, Revisions 5 & 6.

In the AP1000 PRA chapter 55, Section 55.2.1, Westinghouse identified the following COL actions to confirm the seismic margin evaluation that includes generic fragility data:

As part of a COL action, a qualification seismic review of the design will be performed with the purpose of identifying vulnerabilities and confirming the basis of the seismic margin evaluation. For each plant, a verification walkdown will be performed with the purpose of identifying differences in the as built from design and ensuring vulnerabilities were not created.

Design Control Document (DCD) Revision:

None

PRA Revision:

None