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Your ref: Docket No. 52-006
Our ref: DCP/NRC2453

April 29, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 3)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 3. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP-3.8.2-SEB1-04

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
Licensing and Customer Interface
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/Enclosure

1. Response to Request for Additional Information on SRP Section 3

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NRO

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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 3

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP-3.8.2-SEB1-04
Revision: 0

Question:

DCD Section 3.8.2.4.1.2, which describes the local analyses for the penetrations of the steel containment, has been revised. Westinghouse is requested to address the following items related to this section of the DCD:

1. This DCD section refers to Figure 3.7.2-7 which does not exist. This should be corrected. If the intended figure is 3.8.2-7, then Westinghouse is requested to provide a legible figure so that the information in the model can be reviewed and the legible figure should be placed in the DCD.

2. This DCD section indicates that the global seismic loads are applied as equivalent static accelerations using the maximum accelerations from the nuclear island stick model given in DCD Table 3.7.2-6. Westinghouse is requested to provide this table in the DCD because it can not be located.

3. Provide a more detailed explanation of (1) the new 3-D finite element model of the entire containment described in Section 3.8.2.4.1.2, used for the local evaluation near penetrations and (2) the axisymmetric model described in Section 3.8.2.4.1.1 and Appendix 3G which has not changed and is used for the analysis of the containment in regions away from penetrations. Since the axisymmetric model is not expected to be as detailed as the 3-D model and has some limitations for certain loads such as seismic, how do the results of the new and probably more accurate 3-D finite element model compare with the results of the axisymmetric model for the governing load combinations at the most critical locations of the containment?

4. Describe the "less refined dynamic model" and the analysis described in DCD Section 3.8.2.4.1.2, which was used in a time history analysis to determine the local amplified seismic response. Also, explain what is meant by the amplified local seismic responses are applied separately for each of the four penetrations. If the global analysis was performed separately for each of the four sets of penetration loads, then how were the containment responses combined from these four separate seismic analyses and how were these responses then combined with the other global containment responses due to all loads?

If your response to this request for additional information will reference Revision 17 to the AP1000 DCD, please provide an exact reference.

Westinghouse Response:

DCD Section 3.8.2.4.1.2 provides a summary of the local analyses of the steel containment vessel large penetration regions, and associated figures. Details of the analyses and magnified figures with legible details are included in Westinghouse Technical Report APP-GW-GLR-005

(TR09) 'Containment Vessel Design Adjacent to Large Penetrations', which is referenced from the DCD. Revision 2 of APP-GW-GLR-005 is being transmitted concurrent with this RAI response.

1. The intended figure reference in DCD Section 3.8.2.4.1.2 for the finite element model is 3.8.2-7. DCD Section 3.8.2.4.1.2 will be revised to correct the reference to the figure.

   Larger figures with legible details are included in Technical Report APP-GW-GLR-005

2. Response: DCD Section 3.8.2.4.1.2 includes only a summary of the local analyses of the steel containment vessel large penetration regions.

   In DCD Revision 15, Table 3.7.2-6 was 'Maximum Absolute Nodal Acceleration (ZPA) Steel Containment Vessel' for hard rock site condition. This table will be added in the DCD as Table 3.8.2-5. The accelerations are the maximum accelerations from the nuclear island stick model on hard rock and are shown in Section 2.5 and Table 2-9 of Technical Report APP-GW-GLR-005 to give a conservative design by comparison against the accelerations in the more recent nuclear island analyses for all soil conditions described in DCD Appendix 3G.

3. The details of the 3-D finite element model of the containment are included in Technical Report APP-GW-GLR-005, "Containment Vessel Design Adjacent to Large Penetrations", which is referenced in the DCD.

   A 3-D shell, finite element model of the containment vessel was developed in ANSYS in order to consider the effect of the penetrations and their dynamic response. The large masses and local stiffness of the personnel locks and equipment hatches were discretely modeled. The polar crane was represented by a beam model. The bottom of the model was fixed at elevation 100' where the containment vessel is embedded in concrete.

   The axisymmetric model is more refined in the meridional direction than the 3-D model. Loads such as seismic and polar crane loads are applied by Fourier harmonics. Thus, it gives better results in areas where the shell is axisymmetric. The 3D model was developed for the non-axisymmetric condition around the equipment hatches and personnel airlocks. The 3-D model was also used to solve one static load case representing the dead weight of the polar crane. The static results were favorably compared to results from the axisymmetric model for the same loading.

   The frequencies and mode shapes were calculated both with and without the polar crane included. The modal data without the polar crane was favorably compared to those of the axisymmetric model described in the DCD with the masses of the large penetrations smeared around the circumference, but without the mass of the polar crane.

4. The details are included in Technical Report APP-GW-GLR-005 (Containment Vessel Design Adjacent to Large Penetrations) which is referenced in the DCD. The less refined model was used in dynamic analyses and did not include the refined mesh around the penetrations required for detailed stress evaluation. Application of the amplified local seismic responses and their combination with the global seismic loads are described in Section 2.3 of the report.

References: None

Design Control Document (DCD) Revision:

Revise third paragraph of Subsection 3.8.2.4.1.1 as follows:

The seismic analysis performed envelope all soil conditions. The global seismic loads are applied as equivalent static accelerations using the maximum accelerations shown in Table 3.8.2-5. These accelerations are the maximum accelerations from the nuclear island stick model ~~given in DCD Table 3.7.2-6~~on hard rock. The accelerations are shown in Reference 53 to give a conservative design by comparison against the accelerations in the more recent nuclear island analyses for all soil conditions described in Appendix 3G. The seismic analysis of the nuclear island is discussed in Section 3.7 and Appendix 3G. The torsional moments, which include the effects of the eccentric masses, are increased to account for accidental torsion and are evaluated in a separate calculation.

Revise Subsection 3.8.2.4.1.2 as follows:

3.8.2.4.1.2 Local Analyses

The penetrations and penetration reinforcements are designed in accordance with the rules of ASME III, Subsection NE. The design of the large penetrations for the two equipment hatches and the two airlocks use the results of finite element analyses which consider the effect of the penetration and its dynamic response (Reference 53).

The personnel airlocks and equipment hatches are modeled in a 3-D shell finite element model of the containment. The bottom of the model is fixed at elevation 100′ where the containment vessel is embedded in concrete.

Static analyses are performed using the finite element model shown in Figure 3.8~~7~~.2-7 for internal pressure, dead load (including the polar crane in the parked position), thermal loads and seismic loads.

The global seismic loads are applied as equivalent static accelerations using the maximum accelerations shown in Table 3.8.2-5. ~~from the nuclear island stick model given in DCD Table 3.7.2-6.~~ The amplified local responses are included separately for each of the four penetrations. Local seismic axial and rotational accelerations about both horizontal and vertical axes are applied based on the maximum amplified response determined from a time history analysis on a less refined dynamic model with seismic time histories at elevation 100′.

Stresses are evaluated against the stress intensity criteria of ASME Section III, Subsection NE for the load combinations described in Table 3.8.2-1. Stability is evaluated against ASME Code Case N-284. Local stresses in the regions adjacent to the major penetrations are evaluated in accordance with paragraph 1711 of the code case. Stability is not evaluated in the reinforced penetration neck and insert plate which are substantially stiffer than the adjacent shell.

Static analyses are performed using the finite element model shown in Figure ~~3.7.2-7~~ 3.8.2-7 for internal pressure, dead load (including the polar crane in the parked position), thermal loads and seismic loads. The global seismic loads are applied as equivalent static accelerations using the maximum accelerations from the nuclear island stick model given in DCD Table 3.7.2-6. The amplified local responses are included separately for each of the four penetrations. Local seismic axial and rotational accelerations about both horizontal and vertical axes are applied based on the maximum amplified response determined from a time history analysis on a less refined dynamic model with seismic time histories at elevation 100′.

Table 3.8.2-5

MAXIMUM ABSOLUTE NODAL ACCELERATION (ZPA)
STEEL CONTAINMENT VESSEL

HARD ROCK SITE CONDITION

Elevation (ft)	Maximum Absolute Nodal Acceleration, ZPA (g)					
	N-S Direction		E-W Direction		Vertical Direction	
	Mass Center	Edge	Mass Center	Edge	Mass Center	Edge
281.90	1.48		1.56		1.25	
273.83	1.43		1.50		1.02	
265.83	1.38		1.43		0.85	
255.02	1.31		1.34		0.73	
244.21	1.23	1.28	1.26	1.30	0.68	0.71
224.00	1.09	1.13	1.11	1.17	0.66	0.68
200.00	0.90	0.94	0.94	0.98	0.61	0.63
169.93	0.69	0.71	0.72	0.75	0.53	0.55
162.00	0.63	0.65	0.67	0.68	0.51	0.53
141.50	0.49	0.50	0.54	0.54	0.45	0.47
131.68	0.43	0.44	0.47	0.48	0.41	0.44
112.50	0.40	0.41	0.37	0.38	0.35	0.40
104.12	0.38	0.40	0.38	0.40	0.32	0.38
100.00	0.38	0.40	0.39	0.41	0.31	0.34

Notes:

1. Enveloped response results at the north, south, east, and west edge nodes of the structure are shown. This is the maximum value of the response at any of these edge nodes.
2. Results at elevation 233.50′ are mid span of polar crane bridge.

PRA Revision:
None

Technical Report (TR) Revision:
None