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Your ref: Project Number 740
Our ref: DCP/NRC1734

May 22, 2006

Subject: AP1000 COL Technical Report Submittal

In support of Combined License application pre-application activities, Westinghouse is submitting an AP1000 Standard Combined License Technical report. These reports complete and document, on a generic basis, activities required for COL information items in the AP1000 Design Control Document. This report is submitted as part of the NuStart Bellefonte COL Project (NRC Project Number 740). The information included in this report is generic and is expected to apply to all projects referencing the AP1000 Design Certification.

The purpose for the submittal of this report and the expected pre-application review was explained in a March 8, 2006 letter from NuStart to the NRC.

Pursuant to 10 CFR 50.30(b), APP-GW-GLR-005, Rev. 0, "Containment Vessel Design Adjacent to Large Penetrations," Technical Report Number 9 is submitted as Enclosure 1 under the attached Oath of Affirmation

It is expected that when the NRC review of these reports is complete, the subject COL Information Items will be considered complete for COL applicants referencing the AP1000 Design Certification.

Questions or requests for additional information related to the content and preparation of these reports 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,

A. Sterdis, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

D079

3769alf.doc

/Attachment

1. "Oath of Affirmation," dated May 22, 2006

/Enclosure

1. APP-GW-GLR-005, Rev. 0, "Containment Vessel Design Adjacent to Large Penetrations," Technical Report Number 9.

cc:	S. Bloom	-	U.S. NRC	1A	1E
	G. Curtis	-	TVA	1A	
	L. Dudes	-	U.S. NRC	1A	1E
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	C. Pierce	-	Southern Company	1A	
	E. Schmiech	-	Westinghouse	1A	
	G. Zinke	-	NuStart/Entergy	1A	

ATTACHMENT 1

Oath of Affirmation

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:)

NuStart Bellefonte COL Project)

NRC Project Number 740)

APPLICATION FOR REVIEW OF
"AP1000 GENERAL COMBINED LICENSE INFORMATION"
FOR COL APPLICATION PRE-APPLICATION REVIEW

Stephen R. Tritch, being duly sworn, states that he is President and CEO for Westinghouse Electric Company; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission this document; that all statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

S R Tritch

Stephen R. Tritch
President and CEO

Subscribed and sworn to
before me this 22nd day
of May 2006.

Lorraine M. Piplica
Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Lorraine M. Piplica, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Dec. 14, 2007
Member, Pennsylvania Association Of Notaries

ENCLOSURE 1

APP-GW-GLR-005, Rev. 0

"Containment Vessel Design Adjacent to Large Penetrations"

Technical Report Number 9

AP1000 DOCUMENT COVER SHEET

TDC: ________ Permanent File: ________ APY: ________

RFS#: ________ RFS ITEM #: ________

AP1000 DOCUMENT NO.	REVISION NO.		ASSIGNED TO
APP-GW-GLR-005	0	Page of	W-A. Sterdis

ALTERNATE DOCUMENT NUMBER: WORK BREAKDOWN #:

ORIGINATING ORGANIZATION: Westinghouse Electric Company

TITLE: **Containment Vessel Design Adjacent to Large Penetrations**

ATTACHMENTS:	DCP #/REV. INCORPORATED IN THIS DOCUMENT REVISION:
CALCULATION/ANALYSIS REFERENCE:	

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COL005	Microsoft Word	

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AP1000 RESPONSIBLE MANAGER R. Mandava	SIGNATURE* R Mandava 5/8/06	APPROVAL DATE

* Approval of the responsible manager signifies that document is complete, all required reviews are complete, electronic file is attached and document is released for use.

APP-GW-GLR-005
Revision 0

May 2006

AP1000 Standard Combined License Technical Report

Containment Vessel Design Adjacent to Large Penetrations

Revision 0

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1.0 INTRODUCTION

This report summarizes the final design of containment vessel elements (reinforcement) adjacent to concentrated masses (penetrations). The requirements for these analyses are identified in the AP1000 Design Control Document (DCD, Reference 1) Subsection 3.8.2.4.1.2. The completion of these analyses is identified as COL Information Item 3.8-1 (FSER {Reference 2} Action Item 3.8.2.4.1.2-1) in DCD Subsection 3.8.6.1 to be completed by the Combined License applicant and documented in the ASME Code design report.

> COL Information Item 3.8-1: "The final design of containment vessel elements (reinforcement) adjacent to concentrated masses (penetrations) is completed by the Combined License applicant and documented in the ASME Code design report in accordance with the criteria described in subsection 3.8.2.4.1.2."

This report also addresses the effect of extending the applicability of the AP1000 containment vessel design to soil sites. The global effects of soil sites are addressed in Reference 3. Comparisons of containment vessel response are provided in this report and demonstrate that the design for the hard rock site is also applicable at soil sites.

This report and the associated design calculations available for NRC audit will permit this Combined License information item to be closed.

2.0 TECHNICAL BACKGROUND

Westinghouse design calculations for the general portions of the containment vessel were reviewed by the NRC as part of the AP1000 design certification review. Methodology was described in the DCD (Reference 1) for more detailed analyses in the vicinity of the two equipment hatches and the two personnel airlocks. These more detailed analyses were identified to be completed by the Combined License applicant. These detailed analyses have now been completed and are summarized in this technical report. A design summary report has been prepared summarizing the design and analyses of the containment vessel.

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. These analyses and evaluations are described in the following sections.

2.1 3D model of containment vessel

A 3-D shell, finite element model of the containment vessel (Figure 2-1) 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 are discretely modeled. The polar crane is represented by a beam model (Figure 2-2). The bottom of the model is fixed at elevation 100' where the containment vessel is embedded in concrete.

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.

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.

2.2 Dynamic analyses of 3D model

Time history seismic analyses were run to obtain the local responses of the large penetrations by applying the AP1000 ground motion time histories at the base of the containment vessel model (elevation 100'). This motion is applicable for a hard rock site as shown by the comparison in Figures 2-3 to 2-5 between the response at elevation 100' and the ground motion. This motion is also reasonable for soil sites as discussed in section 2.5.

Table 2-1 shows the maximum absolute accelerations on the axis of the four penetrations. These are given in polar coordinates along and normal to the axis of the each penetration. Table 2-2 shows the equivalent static accelerations specified in the containment vessel design specification which are those obtained from the seismic analyses of the nuclear island stick models given in Table 3.7.2-6 of the DCD. As shown in Tables 2-1 and 2-2, the maximum accelerations from the time history analyses are similar to or lower than those specified in the design specification for the tangential and vertical directions. Note that the penetrations are generally on the east side so the tangential response can be compared to the north-south (X) equivalent static acceleration. In the radial direction accelerations are about 50% higher due to the shell flexibility. For the upper penetrations there is significant radial response and rotation of the airlock in the frequency range of 5 to 6 hertz. This is less noticeable for the lower penetrations due to the restraint at elevation 100'.

The equivalent static accelerations from the design specification impose an east-west global acceleration of 0.37g at elevation 112.5 and 0.54g at elevation 141.5. This is close to the radial direction since the azimuths of the centers of the penetrations range from -67 degrees to – 126 degrees (-23 to 36 degrees from east-west). The additional acceleration to be applied due to shell flexibility is the radial acceleration from Table 2-2 minus these global values as shown in Table 2-3. There is also a rotational acceleration to be considered, particularly for the airlocks which cantilever from the shell. Since the global accelerations of Table 2-2 do not cause rotational response, the full magnitudes shown in Table 2-1 are applied.

2.3 Static analyses of 3D model

Static analyses were performed on a finite element model having greater detail around the penetrations than that described in section 2.1 and used for the time history dynamic analyses in section 2.2. The mesh in the panels around the personnel locks and equipment hatches was refined. Three sub-models were generated, one for the upper personnel lock, one for the upper equipment hatch, and one combined sub-model for the lower personnel lock and equipment hatch. The coarsely meshed panels around the openings in the dynamic model were replaced by the refined mesh panels. The refined model used in static analyses to evaluate the large penetrations is shown in Figure 2-6(a). The refined submodel for the upper equipment hatch is shown in Figure 2-6(b).

<u>Individual Load Cases</u>

Static analysis runs were made for internal pressure, dead load (including the polar crane in the parked position), thermal loads and seismic loads. The seismic cases consider both global accelerations and local axial and rotational accelerations about the horizontal and vertical at the large penetrations.

Global seismic loads were applied in three load cases using the accelerations from the nuclear island stick model given in DCD Table 3.7.2-6 (X, Y, Z parallel to the three global axes of the containment vessel model). These equivalent static accelerations vary as a function of elevation. They are applied to the model using nodal forces. The forces are calculated for each node in the model using the product of acceleration times mass at a node. The acceleration is linearly interpolated based on the elevation of the node. The mass is the total contributing mass from all the elements at the node. Seismic loads from the polar crane were also applied as equivalent static forces.

Unit Load Cases

The global loads described in the previous paragraph do not include the local amplified response of the large penetrations. These amplified local responses are included separately. Three individual seismic cases consider local axial and local rotational accelerations about both horizontal and vertical axes for each of the four penetrations, making a total of twelve cases, as shown in Table 2-3. The local accelerations were applied to the mass of each large penetration and its reinforcement and a band of shell plate surrounding the reinforcement. The linear acceleration is applied parallel to the axis of the penetration. This linear acceleration is additive to the acceleration already applied to the penetration as part of the global accelerations. The rotational accelerations are applied about the horizontal and vertical axes orientated perpendicular to the axis of the penetration (tangential to the shell and vertical). The three axes, radial, tangential and vertical have their origins at the intersection of the axis of the penetration and the mid-surface of the vessel shell.

The local accelerations were applied to the model using forces acting at the penetration neck/reinforcement junction. The linear/rotational mass of the penetration, neck, reinforcement and surrounding shell was multiplied by the linear/rotational acceleration, respectively. The total force due to a local acceleration was distributed around the neck/reinforcement junction using forces acting parallel to the axis of the penetration. The distribution was uniform for the linear acceleration; and varied by the cosine and sine functions (local polar coordinates along axis of penetration) for the two rotational accelerations, respectively.

Combination of SSE loads

The twelve local analysis cases are based on the maximum radial and rotational accelerations from the time history analyses. These cases then represent the local shell response in individual modes. Global and local acceleration loads are assumed in-phase and stress results are added algebraically.

- The North-South (X) global results are combined with the local "rotation about the vertical axis" acceleration results.
- The East-West (Y) global results are combined with the "radial" local results.
- The Vertical (Z) global results are combined with the local "rotation about the horizontal axis" acceleration results.

The combined global and local seismic load cases are then combined for the three directions of input using either the square root sum of the squares method or the 100%, 40%, 40% method (as described in DCD subsection 3.7.2.6) and then added with dead weight, pressure and thermal stress results in accordance with the load combinations given in DCD Table 3.8.2-1. External pressure is scaled from the internal pressure load case.

2.4 Stress and buckling evaluation adjacent to large penetrations

2.4.1 External pressure and thermal loads

Design conditions for the containment vessel are specified as:

- Design Pressure — 59 PSIG at design temperature of 280°F
- External Pressure — 2.9 PSIG at design temperature of 70°F

Both the maximum external pressure and the temperature conditions are affected by the ambient temperature. Combinations of normal temperature and external pressure are evaluated as service conditions as follows:

Service Level A

- Dead load, uniform temperature of 70F, design external pressure of 2.9 psid
- Dead load, cold weather temperature distribution one hour after loss of all AC power, reduced pressure of 0.9 psid one hour after loss of all AC power in cold weather. This conservatively includes the low probability loss of all AC event as a normal operating condition.

Service Level D

- Dead load, uniform temperature of 70F, SSE, design external pressure of 2.9 psid
- Dead load, cold weather temperature distribution one hour after loss of all AC power, SSE, reduced pressure of 0.9 psid one hour after loss of all AC power in cold weather

Two temperature conditions are considered corresponding to plant operation during cold weather with the outside air temperature at the minimum value of -40F and during hot weather with the outside air temperature at 115F. The cold weather operation results in a significant temperature differential in the vicinity of the horizontal stiffener at elevation 131' 9". The vessel above the stiffener is exposed to the outside air in the upper annulus. This cold weather condition is assumed concurrent with the pressure reduction resulting from loss of all AC and is conservatively assumed as a normal operating condition. It is evaluated during normal operation as a Service level A event. It is also evaluated under Service level D in combination with the Safe Shutdown Earthquake.

The design external pressure of 2.9 psid is based on conservative analyses as described in DCD subsection 6.2.1.1.4. The evaluations are performed with the assumption of a -40°F ambient temperature with a steady 48 mph wind blowing to maximize cooling of the containment vessel. The initial internal containment temperature is conservatively assumed to be 120°F, creating the largest possible temperature differential to maximize the heat removal rate through the containment vessel wall. A negative 0.2 psig initial containment pressure is used for this evaluation. A conservative maximum initial containment relative humidity of 100 percent is used to produce the greatest reduction in containment pressure due to the loss of steam partial pressure by condensation. It is also conservatively assumed that no air leakage occurs into the containment during the transient. Results of these evaluations demonstrate that at one hour after the event the net external pressure is within the 2.9 psid design external pressure.

The extreme conservatism in the above analyses was reduced and an estimate of the external pressure was provided in the response to DSER Open Item 3.8.2.1-1.

With the postulated low outside temperatures, it is physically very unlikely, if not impossible (due to air cooling on the surface of the containment vessel) that the initial containment temperature will ever be 120 degrees F. A WGOTHIC calculation was performed to determine the containment pressure response with the containment initial temperature at as high a value as possible, and with the environment temperature as low as possible. An analysis was performed that determined that the highest containment atmosphere temperature that could occur would be 75F while the reactor is operating and the environment temperature is -40F.

To determine the reduced pressure, the following assumptions were made:

1. Initial containment conditions from steady-state analysis; 75F, 100% relative humidity
2. Internal heat sinks inside containment are assumed to be 75F.
3 Fan coolers remove operating reactor heat so that no net heat load to containment is assumed.
4. Environment temperature assumed to be -40F.
5. Heat transfer coefficients to heat sinks and containment shell are nominal.

Without an internal heat load, the containment atmosphere will cool and the pressure will decrease. The pressure falls from 14.5 psia to 13.6 psia (0.9 psid) at 3600 seconds after the heat input to the containment atmosphere is terminated. This is sufficient time for operator action to prevent further pressure reduction, as discussed in AP1000 DCD Section 6.2.1.1.4. Thus the design value of 2.9 psid external pressure is very conservative.

Note that the 0.9 psid considered in this second case is also conservative since it assumes no net heat load into the containment. Immediately after reactor trip the reactor coolant loop stays hot and heat loads to the containment remain close to those during normal operation. The fan coolers cannot operate with the assumption of loss of all AC; nor would they be expected to be providing cooling when the exterior temperatures are so low.

2.4.2 Stress and buckling evaluation

Stresses are evaluated against the stress intensity criteria of ASME Section III, Subsection NE. Stability is evaluated against ASME Code Case N-284-1. 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.

Initial evaluations showed acceptability for all mechanical loads. Small overstresses existed when thermal stresses were combined with the stresses due to mechanical loads. Local modifications were made in the vicinity of the equipment hatch and the airlock, at the operating deck level, to increase buckling strength. With these modifications, stresses and buckling safety factors have been shown to be within the allowable limits.

2.5 Application of AP1000 at soil sites

The containment vessel design for a hard rock site is described in DCD subsection 3.8.2. This uses seismic input from the nuclear island seismic analyses using the stick models as described in DCD subsection 3.7.2. The nuclear island seismic analyses have been updated and extended to soil sites in Reference 3. These analyses use a fixed base model in ANSYS for hard rock and SASSI for firm rock (FR), upper bound soft-to-medium soil (UB in table, UBSM in figures) and soft-to-medium (SM). The models are 3D shell models for the concrete buildings and a stick model for the containment vessel.

Table 2-4 and Figures 2-7 to 2-9 summarize the maximum absolute acceleration at key elevations of the containment vessel. Figures 2-10 to 2-12 show floor response spectra at elevation 100' at the base of the containment vessel stick.

The second part of Table 2-4 compares the envelope of all soil cases against the design values imposed as equivalent static global accelerations. The acceleration from the controlling soil cases is shown in bold in the upper part of the table. These design values are the maximum accelerations from the nuclear island analyses of the stick model on hard rock described in the DCD. These design values exceed those from all soil cases except for the locations discussed further below which are shown in italics in the lower portion of the table.

Containment vessel global seismic loads

The containment vessel is designed for seismic loads by applying equivalent static accelerations at each elevation based on the maximum acceleration from the nuclear island stick models. The vessel has been evaluated for the equivalent static accelerations tabulated in DCD Table 3.7.2-6 and specified in the *containment* vessel design specification. These accelerations from the stick models are shown as the design values in Table 2-4.

In the Y direction the maximum envelope at elevations 131.68' is 3% higher than the stick model design value. This is not significant to the design of the containment vessel since the horizontal accelerations at elevations 100' and 169.93' are significantly lower than the design values.

In the Z direction the maximum envelope at elevations 100' and 131.68' are 15% higher than the stick models design values. This is due to the fundamental vertical mode of the nuclear island on the soil column; the greatest amplification occurs for the soft to medium soil. This is not significant to the design of the containment vessel since vertical seismic loads are a relatively small contributor to the shell stresses and horizontal accelerations are significantly lower for this soil condition.

Based on these comparisons the design acceleration values used for the global analyses are appropriate for the hard rock and the three soil sites.

Local response of large penetrations

The design in the vicinity of the large penetrations described in the previous paragraphs applies the free field ground motion at the base of the containment vessel. The comparisons shown in Figures 2-3 to 2-5 show this input motion is reasonable for the hard rock sites. Figures 2-10 to 2-12 show floor response spectra at the base of the containment vessel from the seismic analyses on shell models for hard rock and three soil sites. The comparisons show that the free field horizontal ground motion which is similar to the hard rock response is also a reasonable assumption for all soil conditions. However, there is significant vertical amplification particularly in the 4 to 10 hertz range due to the nuclear island mass on the soil spring. Figure 2-12 shows peaks at 3.5 hertz for the soft-to-medium soil, 4.5 hertz for the upper bound and 7.5 hertz for firm rock. These are the fundamental vertical frequencies of the nuclear island on the soil column.

The vertical amplification has only a small effect on the equipment hatches but results in significantly higher response for the airlocks which are cantilevered from the vessel shell. The fundamental frequency of the airlock is in the frequency range of 5 to 6 hertz. The floor response spectrum at elevation 100' in Figure 2-12 shows a response of about 1.44g for the broadened envelope of the soil cases and 0.9 g for the unbroadened hard rock. This increased response was evaluated by increasing the rotational acceleration about the horizontal axis by 60%. The evaluation showed that the vessel met the stress intensity and buckling criteria with this increased response.

2.6 ASME Code Design Specification and Design Report

Design documents for the AP1000 containment vessel are listed in Table 2-5. These documents are available for audit.

The ASME Design Specification is prepared by Westinghouse and specifies design requirements to the containment vessel supplier. This includes equivalent static seismic accelerations based on the seismic time history analyses described in section 3.7 of the DCD and extended to soil sites as described in Reference 3. It also includes additional equivalent static accelerations to be applied to each of the large penetrations based on time history dynamic analyses of the 3D model of the containment vessel.

The summary report plus the detailed calculations and drawings referenced therein is a major portion of the ASME Code Design Report. The ASME Code Design Report for each unit is completed and certified after construction deviations and site related detail design calculations, if any, are addressed. It will eventually include as-built information and will fulfill the ITAAC commitment for the as-built ASME Code Design Report.

The summary report and detail design calculations are available for audit. They include documents already reviewed by NRC as part of the AP1000 Design Certification. They include the analyses and evaluation of the regions adjacent to the large penetrations. They also include detail design documents prepared subsequent to the design certification review.

Table 2-1 Maximum Absolute Accelerations on Axis of Penetrations

				Maximum absolute accelerations (g and radians/sec^2)					
NODE	Elev.	Azimuth	Location	Radial	Tang.	Vert.	Rotx*	Roty*	Rotz*
Upper equipment hatch									
20001	141.50	-67.00	axis	0.750	0.382	0.447	0.104	0.535	0.452
Upper airlock									
20003	138.58	-107.00	axis	0.788	0.381	0.406	0.098	2.540	1.458
Lower equipment hatch									
20002	112.50	-126.00	axis	0.486	0.403	0.321	0.094	0.443	0.388
Lower airlock									
20004	110.50	-107.00	axis	0.568	0.331	0.323	0.083	1.493	1.865

Rotx, roty, and rotz are rotations about local x, y, and z axes, respectively, for each penetration.
The local coordinate system has x along the center line of the penetration, y horizontal and z vertical.

Table 2-2 Equivalent Static Accelerations Specified In Containment Vessel Design Specification (DCD Table 3.7.2-6)

Elevation	N-S Direction		E-W Direction		Vertical Direction	
	Mass center	Edge	Mass center	Edge	Mass center	Edge
			Accelerations (g)			
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

Table 2-3 Equivalent static accelerations to account for local shell flexibility

	Radial acceleration (g)	Rotational acceleration about horizontal axis (radians/sec^2)	Rotational acceleration about vertical axis (radians/sec^2)
Upper equipment hatch	0.21	0.54	0.45
Upper airlock	0.27	2.54	1.46
Lower equipment hatch	0.12	0.44	0.39
Lower airlock	0.20	1.49	1.87

Table 2-4 Maximum absolute acceleration of SCV stick for soil cases

Elev	X-acceleration (g)				Y-acceleration (g)				Z-acceleration (g)			
	HR	FR	UB	SM	HR	FR	UB	SM	HR	FR	UB	SM
SCV												
100.00	**0.329**	0.310	0.328	0.286	0.353	0.329	**0.361**	0.325	0.309	0.308	0.336	**0.357**
131.68	**0.409**	0.359	0.397	0.321	**0.484**	0.461	0.466	0.361	**0.439**	0.366	0.362	0.387
169.93	**0.56**	0.494	0.526	0.344	0.608	**0.650**	0.594	0.464	**0.547**	0.405	0.414	0.412
224.00	**0.866**	0.819	0.831	0.487	0.914	**1.032**	0.752	0.581	**0.664**	0.487	0.483	0.466
281.90	**1.183**	1.069	1.110	0.600	1.232	**1.374**	0.906	0.653	**1.214**	0.872	0.788	0.769

The acceleration from the controlling soil cases is shown in bold above

Elev	Envelope of soil cases			Maximum acceleration from stick model in DCD Table 3.7.2-6		
	X	Y	Z	X	Y	Z
100.00	0.329	0.361	*0.357*	0.38	0.39	0.31
131.68	0.409	*0.484*	*0.439*	0.43	0.47	0.41
169.93	0.560	0.650	0.547	0.69	0.72	0.53
224.00	0.866	1.032	0.664	1.09	1.11	0.66
281.90	1.183	1.374	1.214	1.48	1.56	1.25

See the text for a discussion of the values shown in italics

HR = Hard Rock
FR = Firm Rock
UB = Upper bound soft-to-medium
SM = Soft-to-medium

Table 2-5 Containment Vessel Design Documents

Document number	Title	Notes
APP-MV50-Z0-001, Rev 3	Containment Vessel Design Specification	(1)
APP-MV50-Z0C-001, Rev 0	Miscellaneous Calculations for Containment Vessel Design Specification (update of AP600 calculation MV50-S2C-001, Rev 1)	(2)
APP-MV50-S2C-009, Rev 0	Time history analyses of 3D Model of Containment	(2)
APP-MV50-S2C-003, Rev 0	Containment Vessel Pressure Capacity Capabilities	(4)
APP-MV50-S3R-003, Rev 0	Containment Vessel ASME Design Summary Report	(3)
APP-MV50-S2C-001, Rev 0	Containment Vessel Seismic Model (axisymmetric and stick models)	(4)
APP-MV50-S2C-002, Rev 0	Design of Containment Vessel for Internal and External Pressure	(4)
APP-MV50-S2C-004, Rev 0	Containment Vessel Design, Polar Crane Loads on Shell Analysis	(4)
APP-MV50-S2C-005, Rev 0	Containment Vessel Design, Seismic Analysis With Polar Crane	(4)
APP-MV50-S2C-006, Rev 1	Stress Evaluation Calculations	(4)
APP-MV50-S2C-007, Rev 0	Containment Vessel Displacements and Stresses due to Axisymmetric Temperatures	
APP-MV50-S2C-008, Rev 0	3D Model - Modal Analysis of Containment	
APP-MV50-S2C-010, Rev 0	3D Model - Analysis of Large Penetrations	
APP-MV50-S2C-012, Rev 0	Finite Element Analysis of Three Typical Penetrations	

Notes:

1. Rev 1 was basis for hard rock design certification
2. These documents provide inputs to the design specification
3. Summary report covers design in accordance with the ASME design specification. It references and summarizes design documents listed subsequently in this table.
4. These calculations were reviewed by NRC as part of AP1000 hard rock design certification

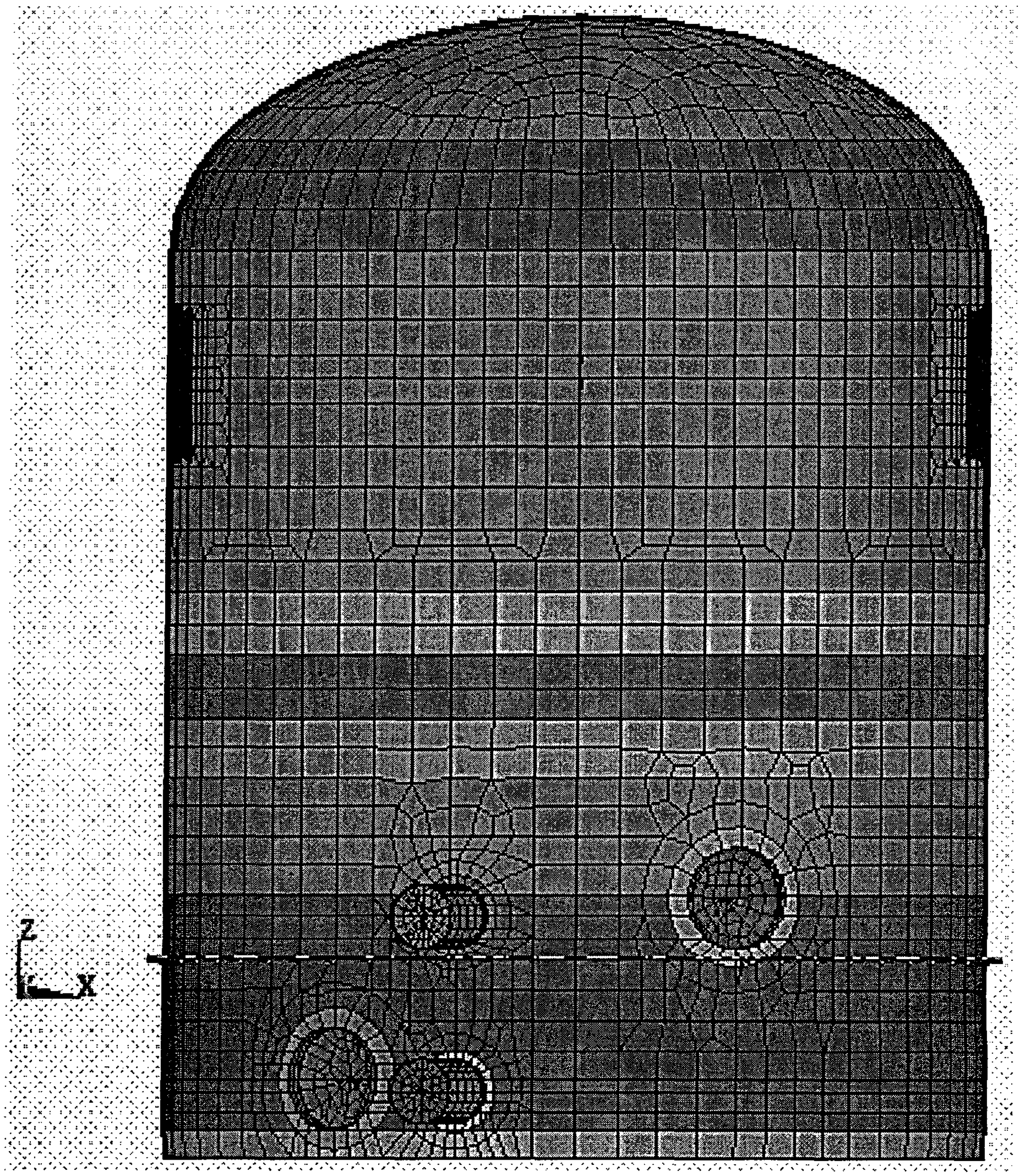

Figure 2-1 3D dynamic model of containment vessel

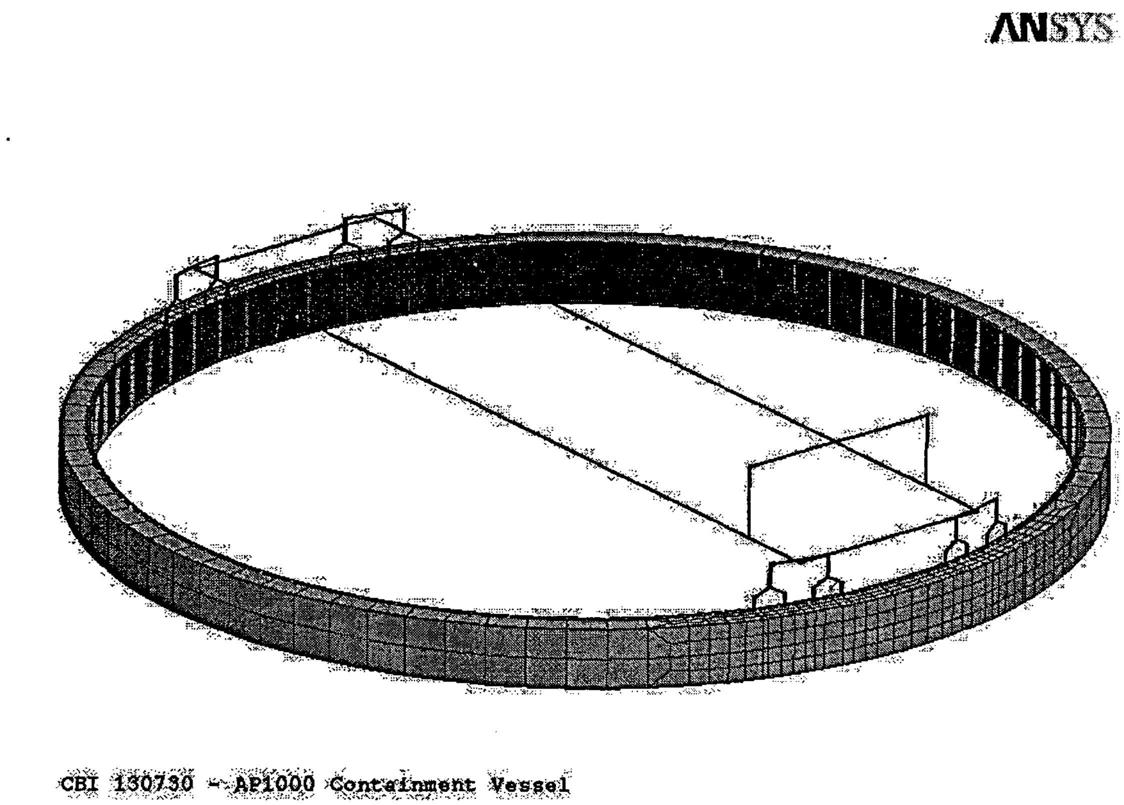

Figure 2-2 Polar crane and crane girder

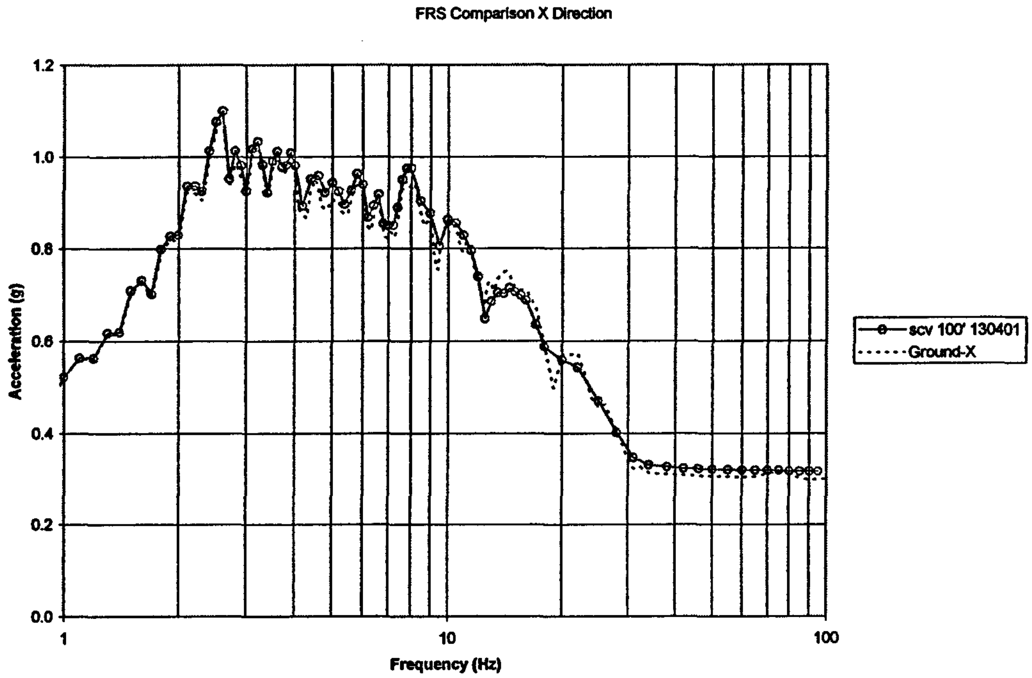

Figure 2-3 FRS (X) at base of NI10 containment vessel for hard rock versus ground input

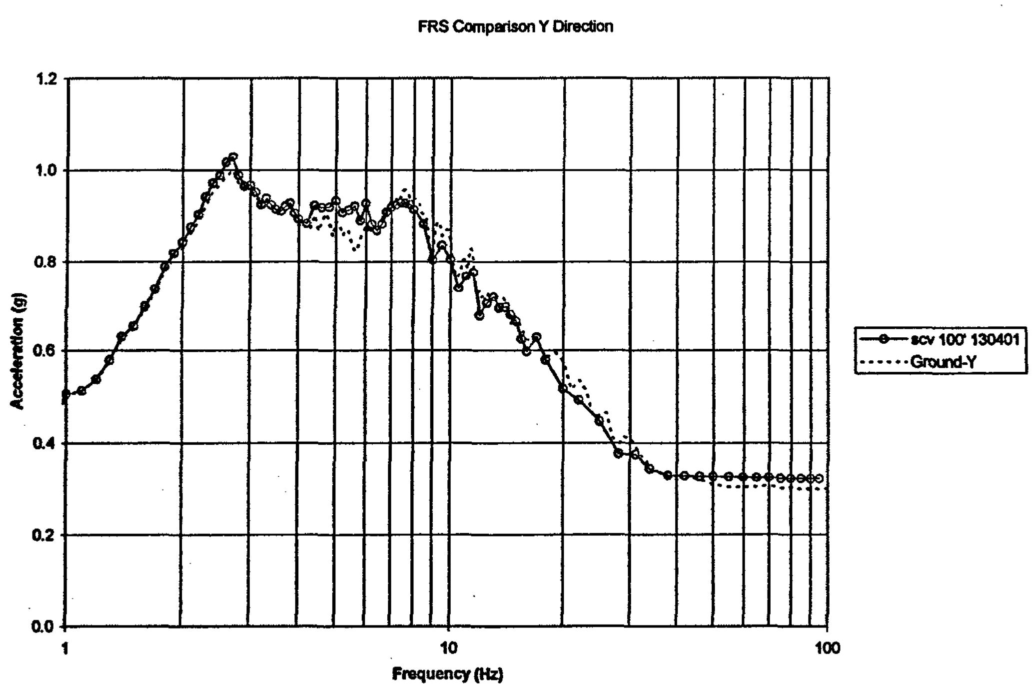

Figure 2-4 FRS (Y) at base of NI10 containment vessel for hard rock versus ground input

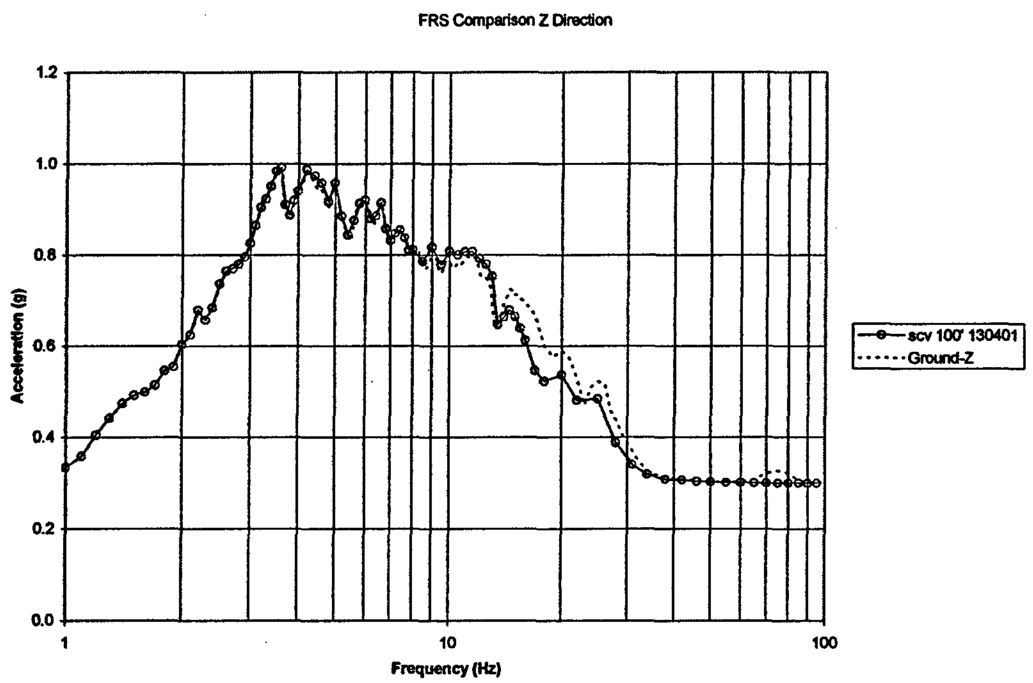

Figure 2-5 FRS (Z) at base of NI containment vessel for hard rock versus ground input

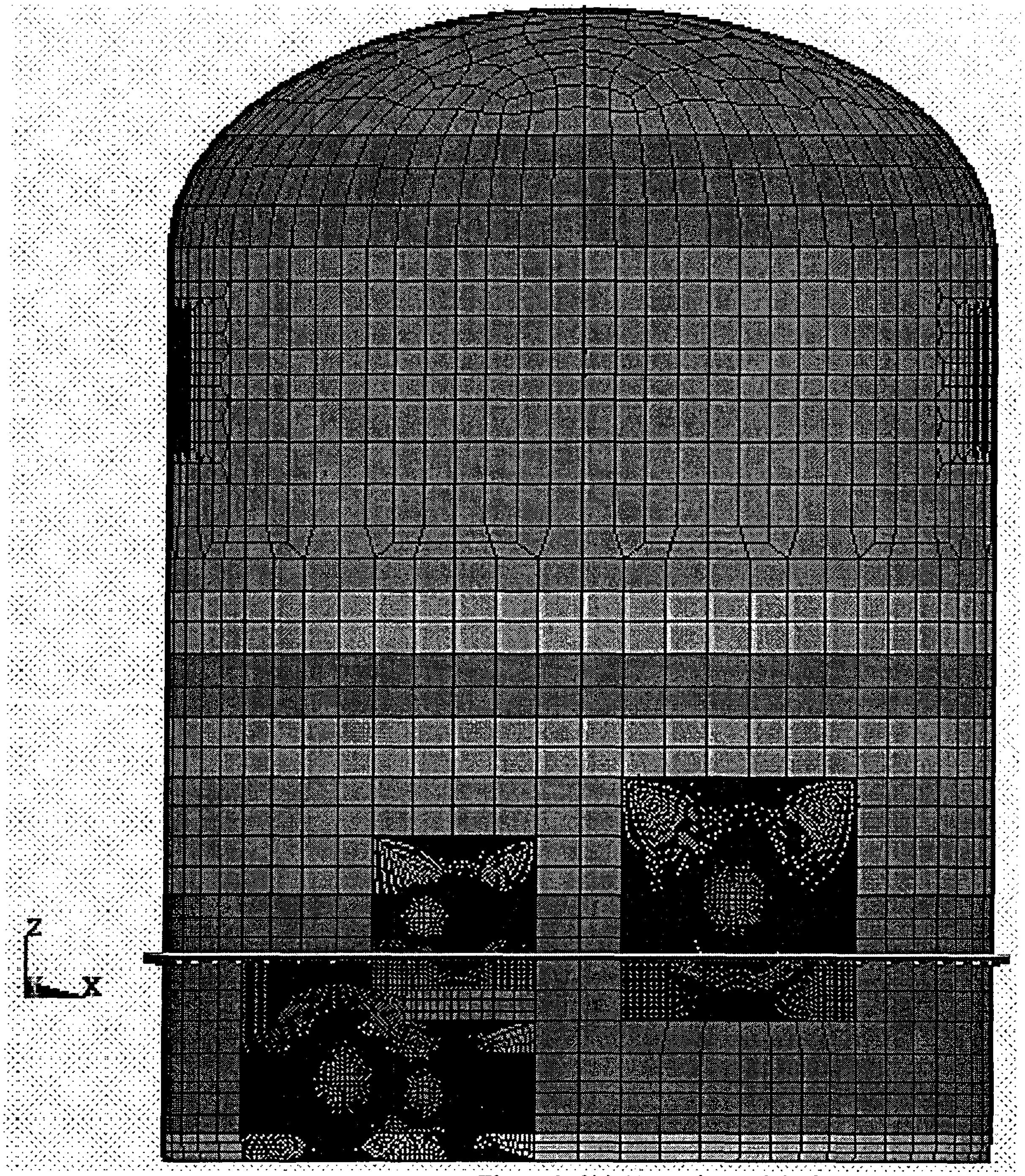

Figure 2-6(a) 3D static model of containment vessel

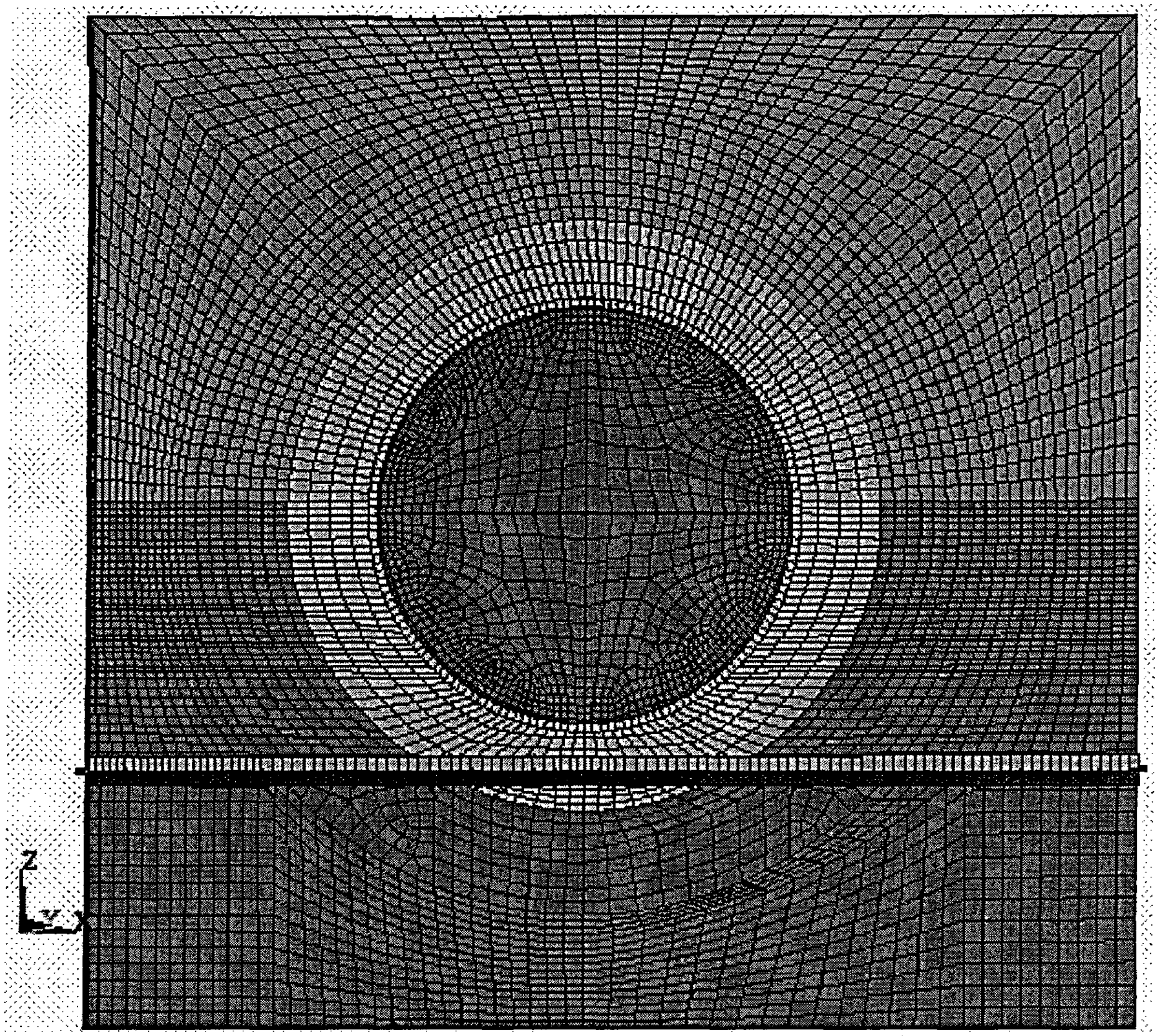

Figure 2-6(b) – Equipment Hatch (El. 141′-6″) Panel (Viewed from 67° azimuth)

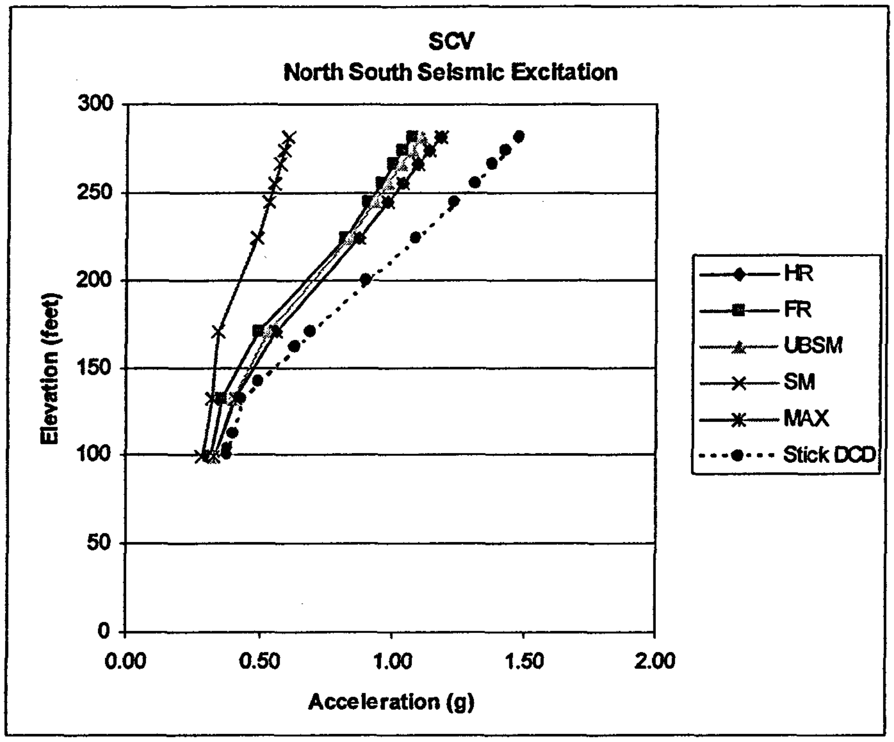

Figure 2-7 Steel containment vessel ZPA North South

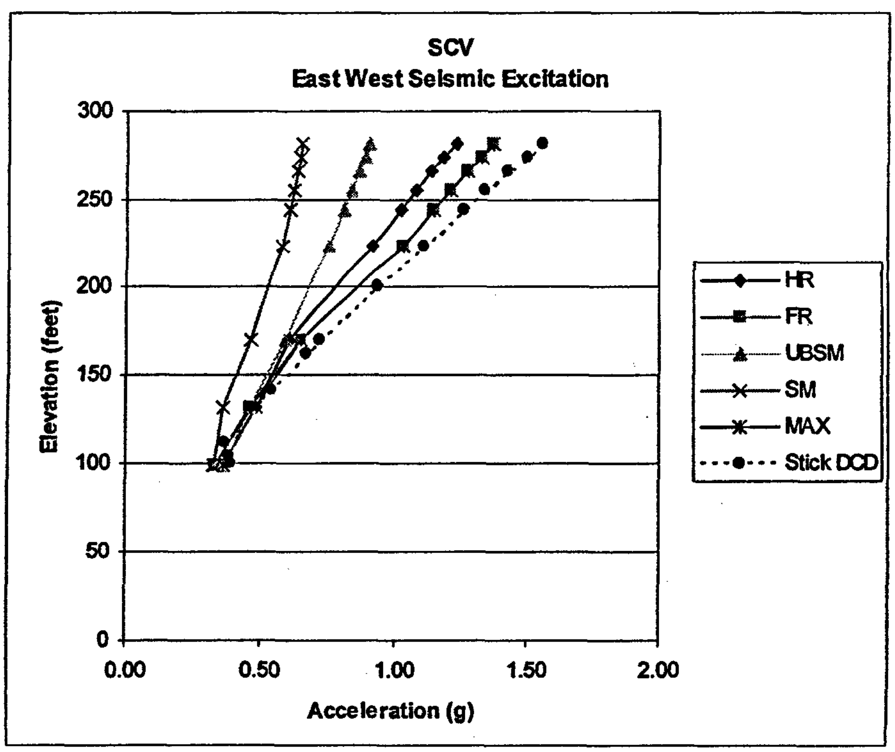

Figure 2-8 Steel containment vessel ZPA East West

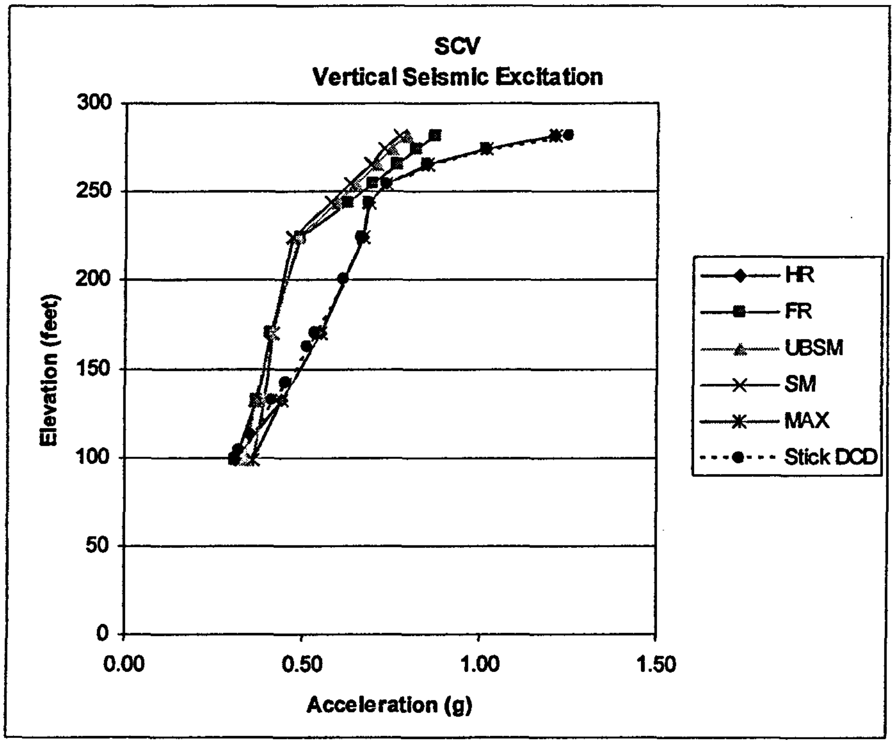

Figure 2-9 Steel containment vessel ZPA Vertical

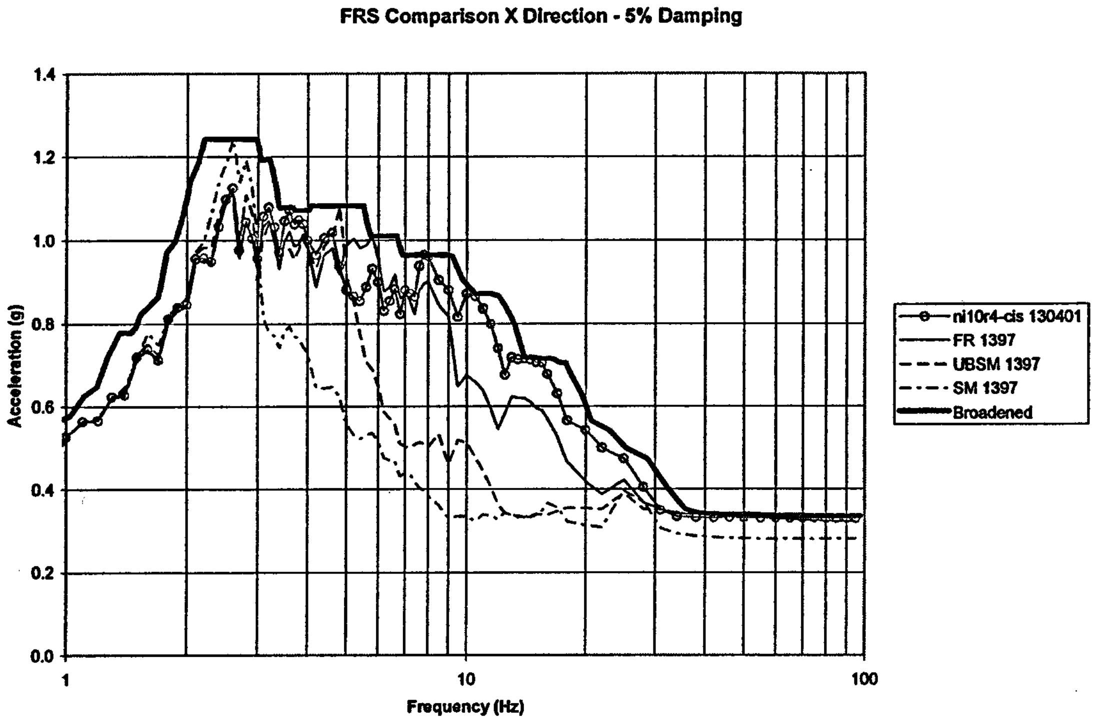

Figure 2-10 Floor Response Spectra (X) at Elevation 100' for Soil Cases

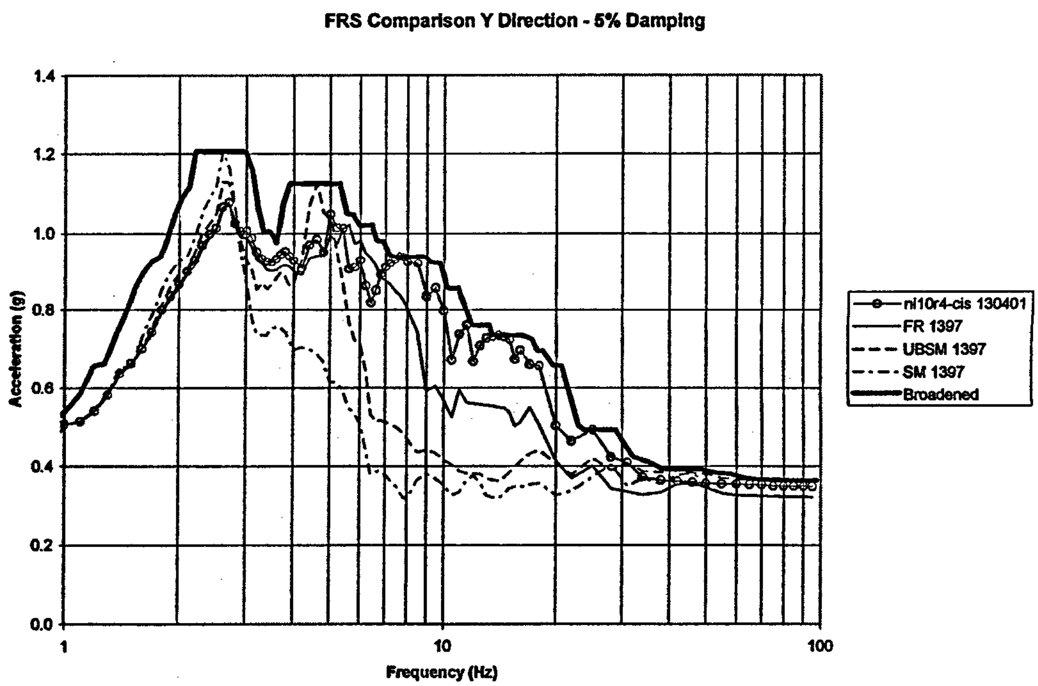

Figure 2-11 Floor Response Spectra (Y) at Elevation 100' for Soil Cases

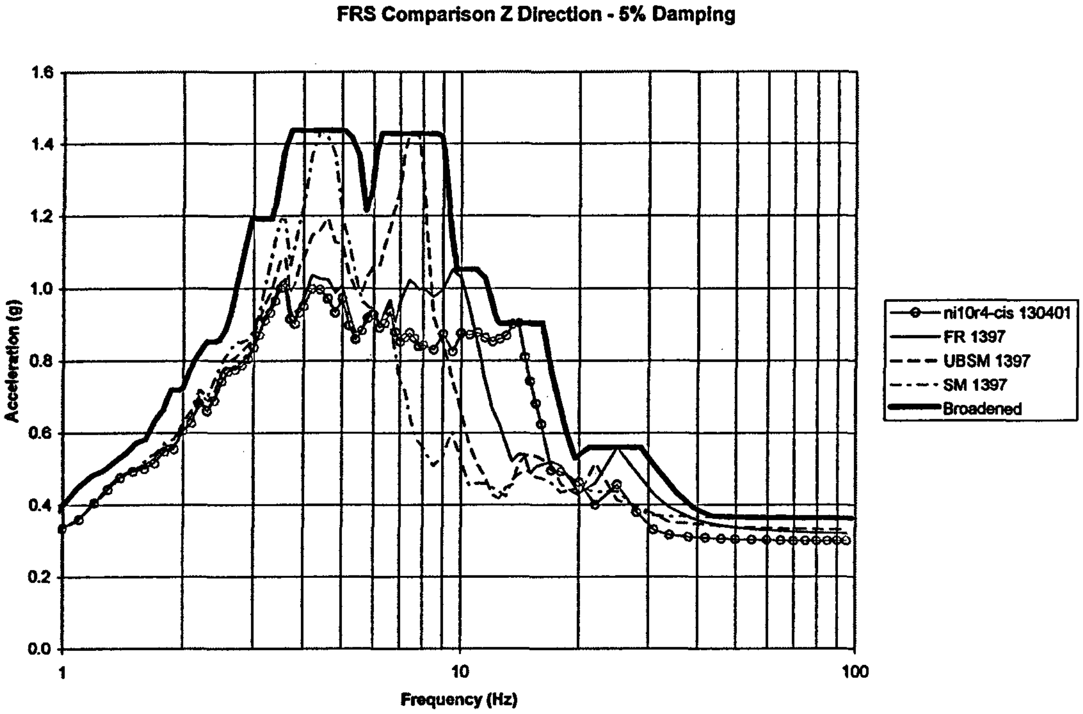

Figure 2-12 Floor Response Spectra (Z) at Elevation 100' for Soil Cases

3. REGULATORY IMPACT

The design of the containment vessel adjacent to the large penetrations is addressed in subsection 3.8.2.4.1.2 "Local Analyses" of the NRC Final Safety Analysis Report (FSER, Reference 2) write-ups. The completion of the analysis for the large penetrations is identified in the FSER as COL Action Item 3.8.2.4.1.2-1. Completion of the design of the large penetrations will impact these write-ups. The conclusions in the FSER about the local analyses are not altered.

The changes to the DCD presented in this report do not represent an adverse change to the design functions, including the pressure boundary integrity functions and the access function, or to how design functions are performed or controlled. The analysis of the large penetrations is consistent with the description of the analysis in 3.8.2.4.1.2 of the DCD. Therefore, the changes to the DCD do not involve revising or replacing a DCD-described evaluation methodology. The changes to the DCD do not involve a test or experiment not described in the DCD. The DCD change does not require a license amendment per the criteria of VIII. B. 5.b. of Appendix D to 10 CFR Part 52.

Since completion of the local analyses does not change the design or design functions of the containment or penetrations, the DCD change does not affect resolution of a severe accident issue and does not require a license amendment based on the criteria of VIII. B. 5.c of Appendix D to 10 CFR Part 52.

The closure of the COL Information Item will not alter barriers or alarms that control access to protected areas of the plant. The closure of the COL Information Item will not alter requirements for security personnel. Therefore, the closure of the COL Information Item does not have an adverse impact on the security assessment of the AP1000.

4. REFERENCES

1. APP-GW-GL-700, AP1000 Design Control Document, Revision 15.
2. Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design, September 2004.
3. APP-GW-GLR-015, Revision 0, Extension of Nuclear Island Seismic Analyses to Soil Sites

5. DCD MARK UP

The following DCD markup identifies how COL application FSARs should be prepared to incorporate the subject change.

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.
The <u>personnel</u> airlock<u>s</u> and equipment hatch<u>es</u> are modeled in <u>a 3-D shell</u> finite element model <u>of the containment</u>. <u>The bottom of the model is fixed at elevation 100' where the containment vessel is embedded in concrete.</u>

<u>Static analyses are performed using the finite element model shown in Figure 3.8.2-7 for internal pressure, dead load (including the polar crane in the parked position), thermal loads</u>

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'.

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-284-1. 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.

Revise Subsection 3.8.6.1 as follows:

3.8.6.1 Containment Vessel Design Adjacent to Large Penetrations

Completed. The design of containment vessel elements (reinforcement) adjacent to concentrated masses (penetrations) is described in subsection 3.8.2.4.1.2.

Revise Table 3.8.2-1 as follows:

Table 3.8.2-1

LOAD COMBINATIONS AND SERVICE LIMITS FOR CONTAINMENT VESSEL

Load Description		Load Combination and Service Limit											
		Con	Test	Des.	Des.	A	A	A	C	D	C	D	D
Dead	D	x	x	x	x	x	x	x	x	x	x	x	x
Live	L	x	x	x	x	x	x	x	x	x	x	x	x
Wind	W	x				x							
Safe shutdown earthquake	E_s								x	x		x	x
Tornado	W_t										x		
Test pressure	P_t		x										
Test temperature	T_t		x										
Operating pressure	P_o										x		
Design pressure	P_d			x			x		x			x	
External pressure (2.9 psid)	P_e				x			x		x			
External pressure (0.9 psid)[3]						x							x
Normal reaction	R_o				x	x		x		x	x		
Normal thermal	T_o				(4)	(5)		(4)		(4)	(4)		(5)
Accident thermal reactions	R_a			x			x		x			x	
Accident thermal	T_a			x			x		x			x	
Accident pipe reactions	Y_r											x	
Jet impingement	Y_j											x	
Pipe impact	Y_m											x	

Notes:
1. Service limit levels are per ASME-NE.
2. Where any load reduces the effects of other loads, that load is to be taken as zero, unless it can be demonstrated that the load is always present or occurs simultaneously with the other loads.
3. Reduced pressure of 0.9 psid at one hour in loss of all AC transient in cold weather
4. Temperature of vessel is 70F
5. Temperature distribution for loss of all AC in cold weather

Replace Figure 3.8.2-7 by the figure below

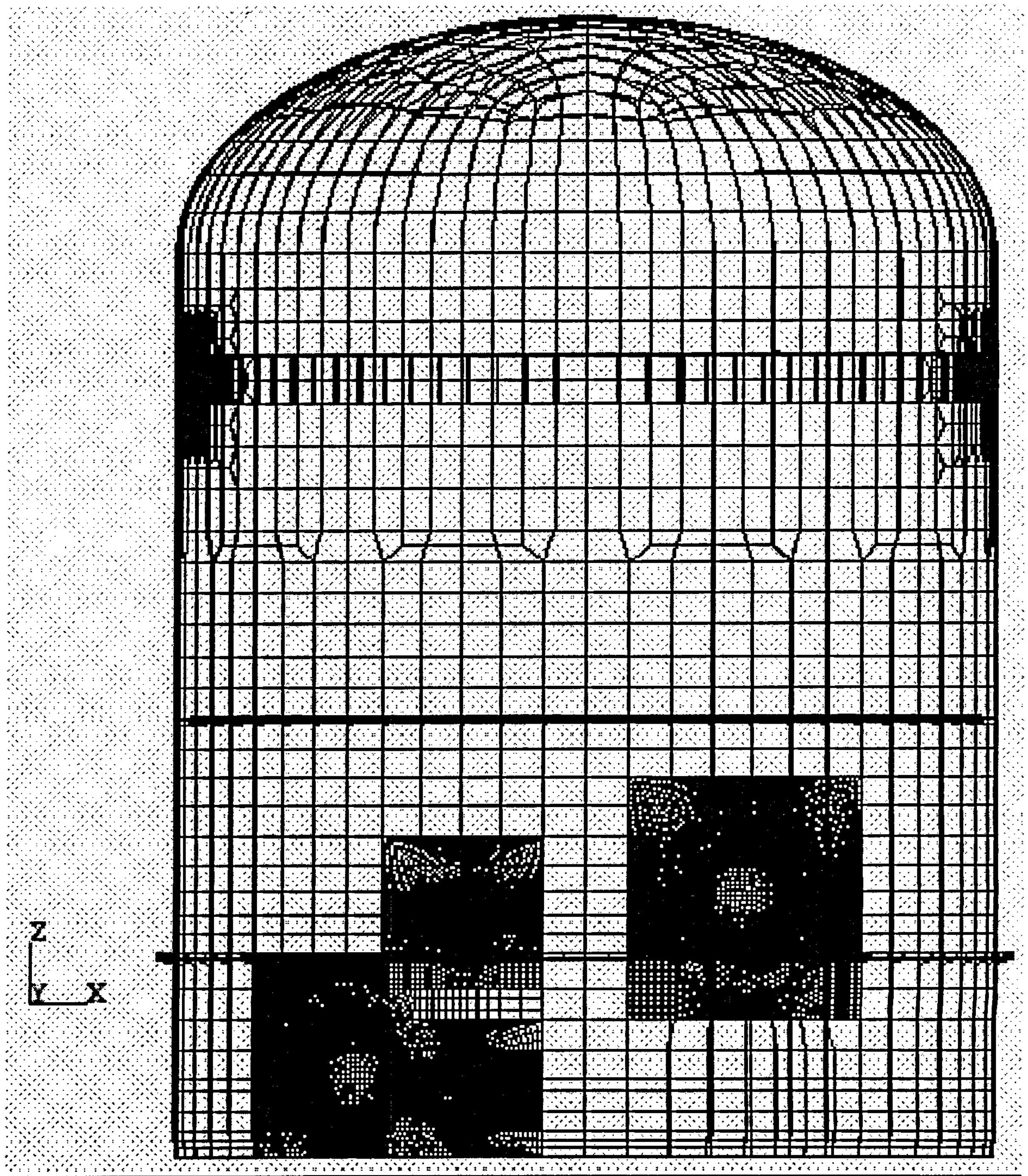

Figure 3.8.2-7
Finite Element Model for Large Penetration Local Analyses