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ENCLOSURE 3

Markup of DCD Revision 18, Section Appendix 3G structure. The nuclear island is embedded approximately 40 feet with the bottom of basemat at elevation 60′-6″ and plant grade located at elevation 100′-0″. The CSV is described in subsection 3.8.2, the CIS in subsection 3.8.3, the ASB in subsection 3.8.4, and the nuclear island basemat in subsection 3.8.5.

Seismic systems are defined, according to SRP 3.7.2 (Reference 1), Section II.3.a, as the seismic Category I structures that are considered in conjunction with their foundation and supporting media to form a soil-structure interaction model. Fixed base seismic analyses are performed for the nuclear island at a rock site. Soil-structure interaction analyses are performed for soil sites. The analyses generate a set of in-structure responses (design member forces, nodal accelerations, nodal displacements, and floor response spectra), which are used in the design and analysis of seismic Category I structures, components, and seismic subsystems. Concrete structures are modeled with linear elastic uncracked properties. However, the modulus of elasticity is reduced to 80% of the ACI code value to reduce stiffness to simulate cracking.

A seismic response spectrum analysis is performed to develop the seismic design loads for the design of the auxiliary building, shield building, and containment internal structure, and the loads generated include the amplified load due to flexibility and the distribution of this load to the surrounding structures. Equivalent static analyses are used to design the shield building roof and radial roof beams, tension ring, air inlet structure, and PCS tank.

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3G.2.1 Individual Building and Equipment Models

3G.2.1.1 Coupled Auxiliary and Shield Building

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

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

3G.2.1.5 Major Equipment and Structures Using Stick Models

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

3G.2.2 Nuclear Island Dynamic Models

Finite element shell models (3D) of the nuclear island concrete structures are used for the time history seismic analyses. Stick models are coupled to the shell models of the concrete structures for the containment vessel, polar crane, the reactor coolant loop and pressurizer. Two models are used. The fine (NI10) model is used to define the seismic response for the hard rock site. The coarse (NI20) model is used for the soil structure interaction (SSI) analyses. It is similar to the NI10 model with the exception that the mesh size for the ASB and CIS is approximately 20 feet instead of 10 feet. This model is set up in both ANSYS and SASSI. The NI05 model is used to develop amplified seismic response for the envelope of soil profiles presented in subsection 3.7.1.4 for flexible regions not captured by the coarser NI20 model. The NI05 model is also used in response spectrum analysis of the nuclear island to develop design seismic member forces and moments. The NI10, NI20, and NI05 models are described in the subsections below.

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3G.2.2.1 NI10 Model

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

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

3G.2.2.2 NI20 Model

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

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3G.2.2.3 Nuclear Island Stick Model

The nuclear island lumped-mass stick model consists of the stick models of the individual buildings interconnected by rigid links. Each individual stick model is developed to match the modal properties of the finite element models described in subsections 3G.2.1.1 and 3G.2.1.2 above. Modal analyses and seismic time history analyses were performed using this model for the hard rock design certification.

The nuclear island lumped-mass stick model has been replaced in the design analyses described in this appendix by the NI10 and NI20 finite element shell dynamic models of the nuclear island described in subsections 3G.2.2.1 and 3G.2.2.2 above. A 2D stick model is used in the soil sensitivity analyses described in subsection 3G.3.

3G.2.2.4 NI05 Model

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The NI05 solid-shell finite element model of the AP1000 nuclear island is shown in Figures 3G.2-13 to 3G.2-15. The NI05 model is used for response spectrum analysis of the nuclear island auxiliary and shield building structures. The NI05 model is also used for the mode superposition time history analysis of the nuclear island for the amplified response at flexible floors. The NI05 model is used for the static analysis of the nuclear island for the basemat design. The NI05 model is a refined version of the NI10 model where the auxiliary and shield building mesh size is reduced from approximately 10 feet by 10 feet tetrahedral mesh to approximately 5 feet by 5 feet. The major equipment stick models supported by the CIS are the same as used for the NI10 model. The steel containment vessel stick model and connections are also the same as the NI10 model. The only difference between the NI05 CIS and NI10 CIS is the basemat (bowl) and dish region as shown in Figure 3G.2-15. The model is validated by a comparison of the mass participation by frequency of the fundamental modes to those of the NI10 model.

3G.2.2.5 Seismic Stability Model

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The sliding stability of the nuclear island basemat is evaluated using a non-linear 2D East-West (EW) stick model of the nuclear island structures using the ANSYS program. Three concentric sticks represent ASB, CIS, and SCV, respectively. The reactor coolant loop is included as mass only. The basemat is modeled as a rigid beam, which is free in translation along the EW and vertical directions. The nuclear island combined sticks are attached to the rigid basemat at the nuclear island mass center.

Each node of the rigid basemat is connected with two spring elements in the horizontal and vertical directions, respectively. The spring elements only model the foundation media (rock or soil) damping, not stiffness. A layer of contact elements is added along the rigid basemat bottom to simulate the friction forces between basemat bottom and foundation media as well as foundation media stiffnesses. The friction coefficient between the basemat bottom and the soil media is set at 0.55. Figure 3G.2-19 shows the schematic of this non-linear 2D EW nuclear island stick model. The contact elements are free to uplift when the upward force (normal force) is larger than the associated dead load component. When the tangential force is larger than the friction force, sliding occurs.

3G.2.3 Static Models

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

Finite element solid/shell models were used for the equivalent static seismic analysis. For the detailed design of the shield building roof, a finite element model of one quadrant of the roof is used as described in subsection 3G.2.3.1. For the detailed design of the steel containment vessel, a shell mesh finite element model with a much finer mesh in the areas surrounding the major penetrations is used as described in subsection 3G.2.3.2. For the static analysis of the containment vessel, an axisymmetric model is used as described in subsection 3G.2.3.3. The nuclear island basemat is evaluated using the NI05 finite element model described in subsection 3G.2.2.4.

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3G.2.3.1 Quadrant Model of Shield Building Roof

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The one quadrant model of the shield building roof is shown in Figure 3G.2-16. The model is constructed with solid and shell elements and contains structures from the exposed shield wall through the top of the shield building roof. The quadrant model is used for the equivalent static analysis of the shield building roof. The results from the more detailed analysis are used in the design of the shield building roof and radial roof beams, tension ring, air inlet structure, and PCS tank.

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3G.2.3.2 Containment Vessel 3D Finite Element Model

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The 3D finite element model of the steel containment vessel is shown in Figure 3G.2-17. The finite element model for the steel containment vessel is used for the stress analysis of the large penetrations (personnel locks and equipment hatches) of the containment vessel.

3G.2.3.3 Containment Vessel Axisymmetric Model

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The axisymmetric finite element model of the steel containment vessel is shown in Figure 3G.2-18. The axisymmetric model is a two-dimensional model with added mass for the stiffeners, crane girder, equipment hatches, and air locks.

In subsection 3.7.2.6, "Three Components of Earthquake Motion," the combination of three components of earthquake motion is discussed.

3G.4.3.2 Absolute Accelerations

The seismic analyses results, which include the new shield building configuration described in Section 3.8, are given in Reference 3.

3G.4.3.3 Seismic Response Spectra

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

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The in-structure response spectra at six key locations, as defined below, are used if a site-specific 3D dynamic analysis evaluation as outlined in subsection 2.5.2.3.2 is required. The site is acceptable if the floor response spectra from the site-specific evaluation do not exceed the AP1000 spectra for each of the locations identified below or the exceedances are justified.

[FRS Location	*Figure Numbers*
Containment internal structures at elevation of reactor vessel support	*Figure 3G.4-5X to 3G.4-5Z*
Containment operating floor	*Figure 3G.4-6X to 3G.4-6Z*
Auxiliary building NE corner at elevation 116'-6"	*Figure 3G.4-7X to 3G.4-7Z*
Shield building at fuel building roof	*Figure 3G.4-8X to 3G.4-8Z*
Shield building roof	*Figure 3G.4-9X to 3G.4-9Z*
Steel containment vessel at polar crane support	*Figure 3G.4-10X to 3G.4-10Z]**

Note:
See Table 3G.4-1 for locations of six key locations.

3G.4.3.4 Bearing Pressure Demand

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

The 2D model was used to evaluate the effect of liftoff on the bearing pressure. Since the largest bearing pressure will result from the east-west seismic excitation because of the smaller width of the basemat in this direction, liftoff was evaluated using an east-west stick model of the nuclear island structures, supported on a rigid basemat with non-linear springs. Direct integration time history analyses were performed. The bearing pressures calculated from these analyses are summarized in Table 3G.4-2. The pressures are at the edge of the basemat. Results are given for

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3G.1-1 (Sheet 1 of 4)

SUMMARY OF MODELS AND ANALYSIS METHODS

Model	Analysis Method	Program	Type of Dynamic Response/Purpose
3D (ASB) solid-shell model	-	ANSYS	Creates the finite element mesh for the ASB finite element model.
3D (CIS) solid-shell model	-	ANSYS	Creates the finite element mesh for the CIS finite element model.
3D finite element model including shield building roof (ASB10)	-	ANSYS	ASB portion of NI10.
3D finite element model including dish below containment vessel	Response spectrum analysis	ANSYS	CIS portion of NI10.
3D finite element shell model of nuclear island [NI10] (coupled auxiliary and shield building shell model, containment internal structures, steel containment vessel, polar crane, RCL, pressurizer, and CMTs)	Mode superposition time history analysis	ANSYS	Performed for hard rock profile for ASB with CIS as superelement and for CIS with ASB as superelement. To develop time histories for generating plant design floor response spectra for nuclear island structures. To obtain maximum absolute nodal accelerations (ZPA) to be used in equivalent static analyses. To obtain maximum displacements relative to basemat.
3D finite element coarse shell model of auxiliary and shield building and containment internal structures [NI20] (including steel containment vessel, polar crane, RCL, and pressurizer)	Mode superposition time history analysis	ANSYS	Performed for hard rock profile for comparisons against more detailed NI10 model.

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Table 3G.1-1 (Sheet 4 of 4)

SUMMARY OF MODELS AND ANALYSIS METHODS

Model	Analysis Method	Program	Type of Dynamic Response/Purpose
3D finite element refined shell model of nuclear island (NI05)	Equivalent static non-linear analysis using accelerations from time history analyses Mode superposition time history analysis for the wall and floor flexibility using synthetic time histories developed to match spectral envelopes applied at the base Response spectrum analysis with seismic input enveloping all soils cases	ANSYS	To obtain SSE member forces for the nuclear island basemat. To obtain floor and wall flexibility response characteristics. To obtain maximum displacements relative to basemat. To obtain SSE member forces for the auxiliary and shield building and the containment internal structures.
3D finite element coarse shell model of auxiliary and shield building and containment internal structures [NI20] (including steel containment vessel, polar crane, RCL, and pressurizer)	Mode superposition time history analysis with seismic input enveloping all soil cases	ANSYS	To obtain total basemat reactions for comparison to reactions in equivalent static linear analyses using NI05 model.
Quadrant model of shield building roof (See subsection 3.8.4.4.1 for information on use of the quadrant model.)	Equivalent static analysis The PCS tank is designed using the maximum accelerations at the ~~applicable elevation~~ resulting from time history dynamic analyses of the nuclear island. The tension ring and air inlet use maximum accelerations that are increased based on results of response spectrum analysis.	ANSYS	To obtain member forces for shield building roof ~~and radial roof beams~~, air inlet structure, tension ring, and PCS tank.

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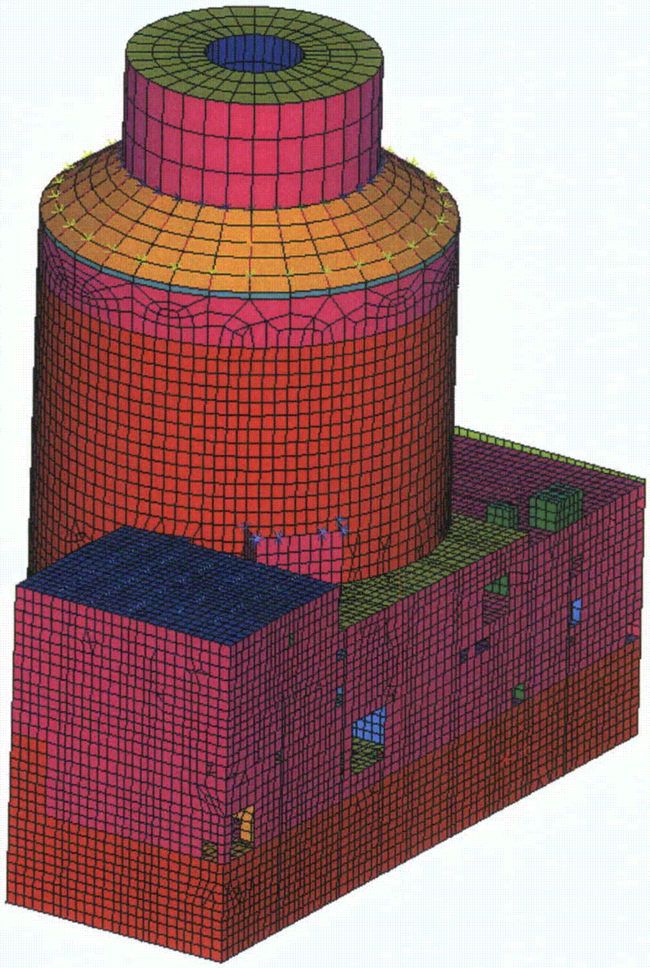

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Figure 3G.2-13

Fine Mesh (NI05) Model of Auxiliary and Shield Building

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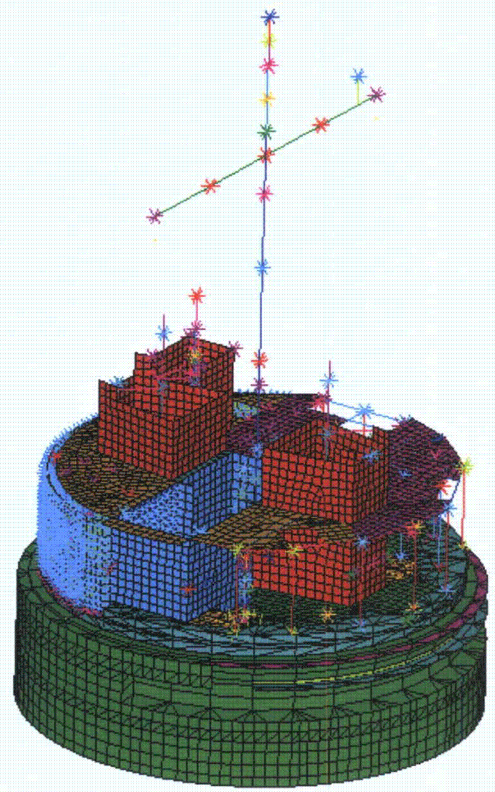

Figure 3G.2-14

NI05 Model of Containment Internal Structures

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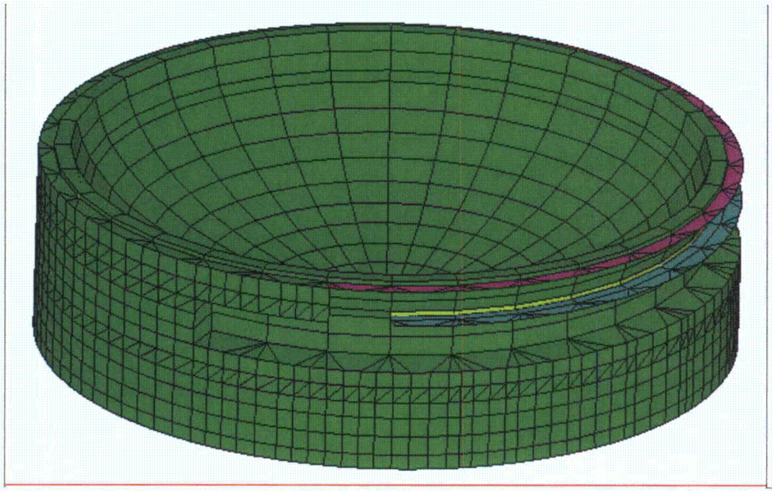

Figure 3G.2-15

3D NI05 Refined Mesh Model of Outer Containment Basemat (Dish)

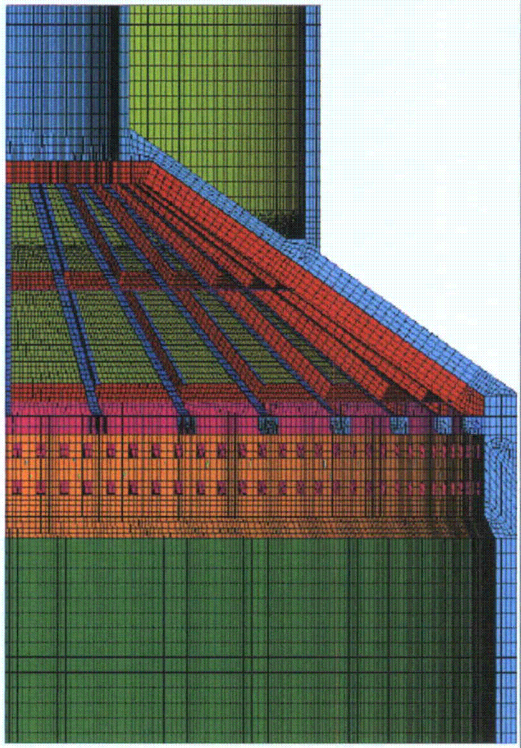

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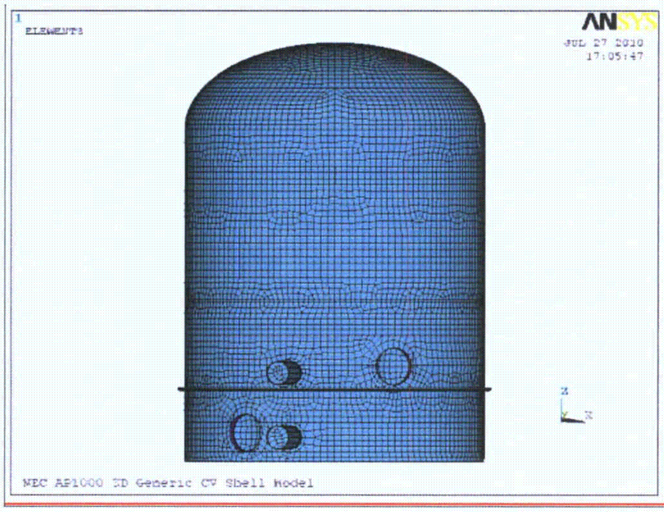
Figure 3G.2-16

Quadrant Model of Shield Building Roof



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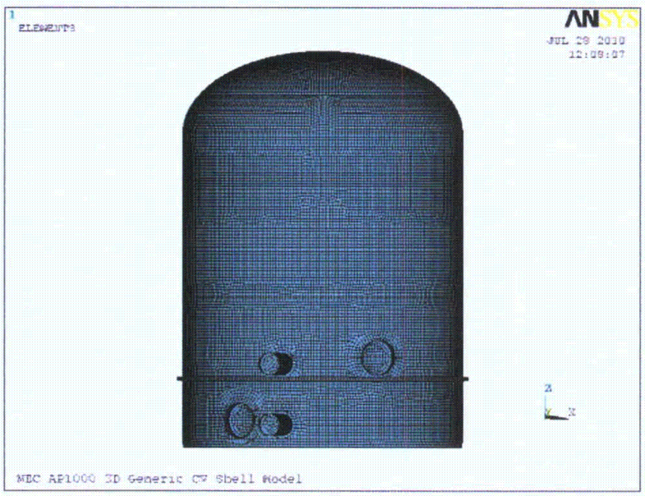
Mesh Size 37″ x 37″



Mesh Size 18″ x 18″

Figure 3G.2-17

Detailed 3D Finite Element Model of Containment Vessel Including Large Penetrations

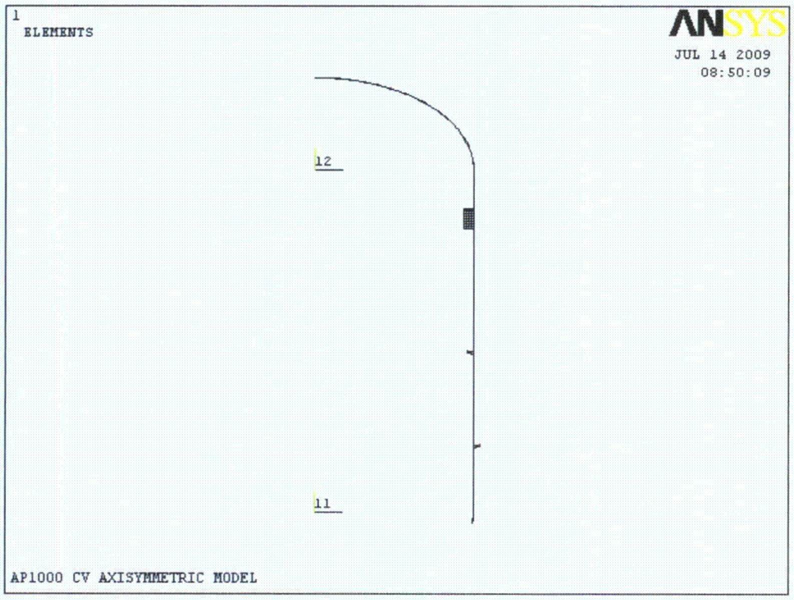


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Figure 3G.2-18

Axisymmetric Model of Containment Vessel

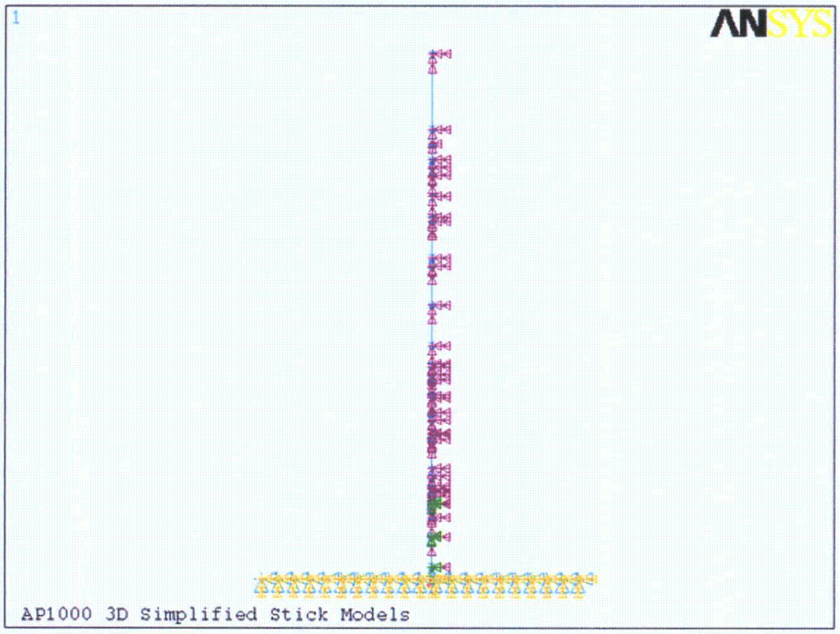

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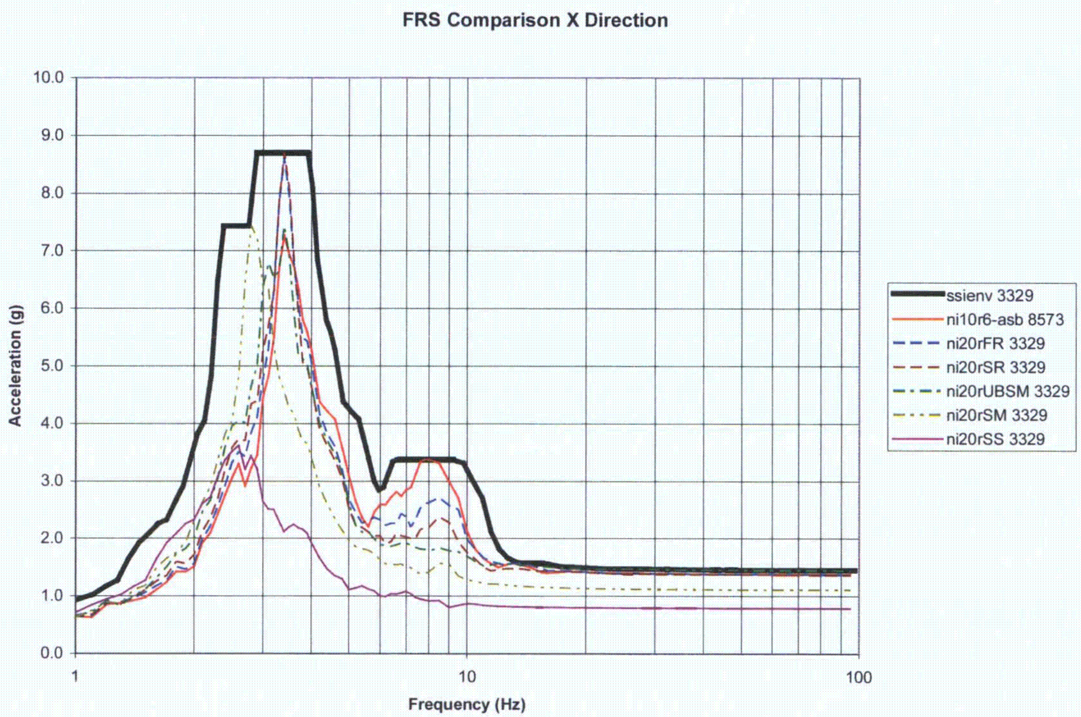
Figure 3G.2-19

Schematic of Non-linear 2D East-West Nuclear Island Stick Model Used for Stability Evaluation that Addresses Sliding and Overturning



[Figure 3G.4-9X

X Direction FRS for Node 8573 (NI10) or 3329 (NI20)
*ASB Shield Building Roof Elevation 327.41']**

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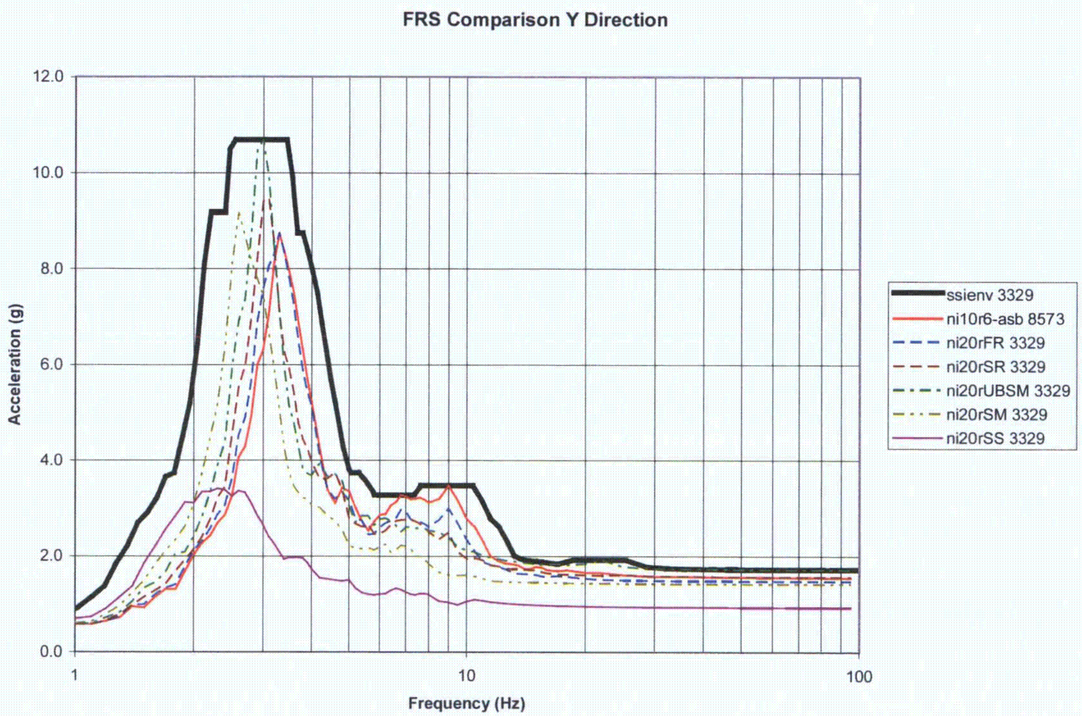
*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.



[Figure 3G.4-9Y

Y Direction FRS for Node 8573 (NI10) or 3329 (NI20)
*ASB Shield Building Roof Elevation 327.41']**

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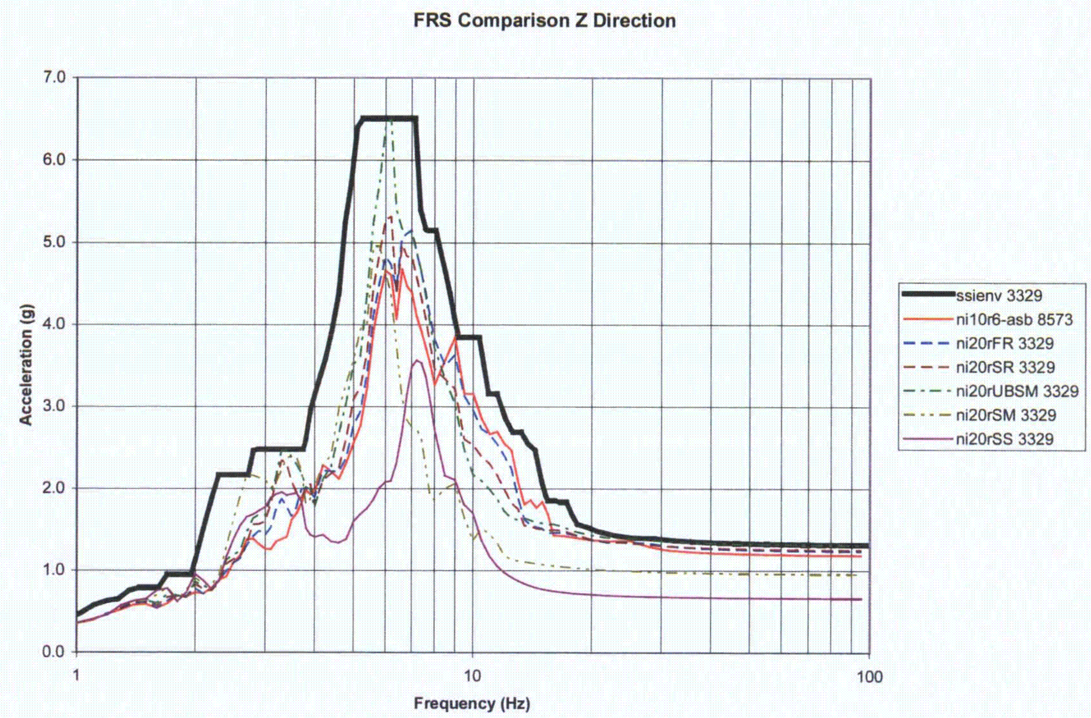
*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.



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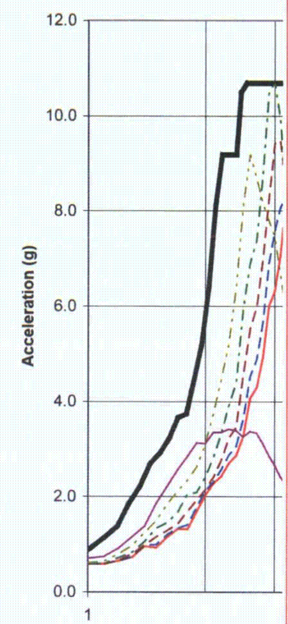

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[Figure 3G.4-9Z

Z Direction FRS for Node 8573 (NI10) or 3329 (NI20)
*ASB Shield Building Roof Elevation 327.41']**

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

ENCLOSURE 4

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APPENDIX 3H

AUXILIARY AND SHIELD BUILDING CRITICAL SECTIONS

3H.1 Introduction

[*This appendix summarizes the structural design and analysis of structures identified as "Critical Sections" in the auxiliary and shield buildings. The design summaries include the following information:*

- *Description of buildings*
- *Governing codes and regulations*
- *Structural loads and load combinations*
- *Global analyses*
- *Structural design of critical structural elements*

Subsections 3H.2 through 3H.5 include a general description of the auxiliary building and shield building, a summary of the design criteria and the global analyses. Examples of the structural design are shown for 14 critical sections which are identified in subsection 3H.5 and shown in Figures 3H.5-1 (3 sheets). The exact locations of the critical sections related to the shield building cylinder shown in Figure 3H.5-16. Representative design details are provided for these structures in subsection 3H.5.]*

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3H.2 Description of Auxiliary and Shield Buildings

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3H.2.1 Description of Auxiliary Building

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[*The auxiliary building is a reinforced concrete structure. The auxiliary building is one of the three buildings that make up the nuclear island and shares a common basemat with the containment building and the shield building. The auxiliary building general layout is shown in Figure 3H.2-1. It is a C-shaped section of the nuclear island that wraps around approximately half of the circumference of the shield building. The building dimensions are shown on key structural dimension drawings, Figure 3.7.2-12.*

The auxiliary building is divided into six areas, which are identified in Figure 3H.2-1. It is a 5-story building; three stories are located above grade and two are located below grade. Areas 1 and 2 (Figure 3H.2-1) have five floors, including two floors below grade level. The lowest floor at elevation 66'-6" is used exclusively for housing battery racks. The next higher floor, at elevation 82'-6", also has battery racks and some electrical equipment. The floor at the grade level, elevation 100'-0", has electrical penetration areas, a remote shutdown workstation room, and some Division A and Division C equipment. The main control room is situated on the floor at elevation 117'-6", which also has rooms for the main steam and feedwater lines. The floor at elevation 135'-3" carries air filtration and air handling units, chiller pumps, and other mechanical and electrical equipment. The roof for areas 1 and 2 is at elevation 153'-0".

Areas 3 and 4 of the auxiliary building are the areas east of the containment shield building. Valve and piping areas, and some mechanical equipment, are located in the basement floor at

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

elevation 66'-6". The floor at elevation 82'-6" has a piping penetration area, a radiation chemistry laboratory, makeup pumps, and other mechanical equipment. The floor at grade level elevation 100'-0" has an electrical penetration room, a staging area for the equipment hatch, and the access opening to the annex building. The electrical penetration area, trip switchgears, and motor control centers occupy most of the floor at elevation 117-6". The floor at elevation 135'-3" is used for the storage of main control room air cylinders and provides access to the annex building. The roof for these areas is at elevation 160'-6".

Areas 5 and 6 include facilities for storage and handling of new and spent fuel. The spent fuel pool, fuel transfer canal, and cask loading and cask washdown pits have concrete walls and floors. They are lined on the inside surface with stainless steel plate for leak prevention. The walls and major floors are constructed using concrete filled steel plate modules. The new fuel storage area is a separate reinforced concrete pit providing temporary dry storage for the new fuel assemblies. A 150-ton cask handling crane travels in the east-west direction. The location and travel of this crane prevents the crane from carrying loads over the spent fuel pool to preclude them from falling into the spent fuel pool. Mechanical equipment is also located in this area for spent fuel cooling, residual heat removal, and liquid waste processing. This equipment is generally nonsafety-related.]*

3H.2.2 Description of Shield Building

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The shield building is the structure and annulus area that surrounds the containment building. It shares a common basemat with the containment building and the auxiliary building. The shield building uses concrete-filled steel plate construction (SC) as well as reinforced concrete (RC) structure. The figures in Section 1.2 show the layout of the shield building and its interface with the other buildings of the nuclear island.

Figure 3.8.4-5 shows the following significant features and the principal systems and components of the shield building:

- Shield building cylindrical structure
- Shield building roof structure
- RC/SC connections
- Air inlets and tension ring
- Knuckle region (connection to exterior wall of PCS tank)
- Compression ring (connection to interior wall of PCS tank)
- Passive containment cooling system (PCS) water storage tank (PCCWST)

The overall configuration of the shield building is established from functional requirements related to radiation shielding, missile barrier, passive containment cooling, tornado, and seismic event protection. These functional requirements led to establishing the design based on two primary design codes used for nuclear plant structures: 1) ACI 349 for reinforced concrete design, and 2) ANSI/AISC N690 for structural steel design.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

The shield building SC walls are anchored to the RC basemat and shield building RC wall by mechanical connections. These RC-to-SC connections are also used in the other regions of the shield building, including:

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- Auxiliary building RC roof connection to the shield building SC wall
- Auxiliary building RC wall connection to shield building SC wall
- Tension ring connection to the shield building RC roof

The connections provide for the direct transfer of forces from the RC reinforcing steel to the SC liner plates.

The cylindrical shield wall has an outside radius of 72.5 feet and a thickness of 36 inches. The cylindrical wall section that is a few feet below the auxiliary building roof line is a reinforced concrete (RC) structure. The section that is not protected by the auxiliary building is a steel concrete (SC) composite structure (see Figure 3H.5-16). The overall thickness of 36 inches is the same as the RC wall below. The concrete for the SC portion is standard concrete with compressive strength of 6000 psi. The SC portion is constructed with steel surface plates, which act as concrete reinforcement. The 0.75-inch tie bars are welded to the steel faceplates to develop composite behavior of the steel faceplates and concrete. The shear studs are welded to the inside surface of the steel plate. The tie bar spacing is reduced in the higher stress regions. A typical SC wall panel is shown in Figure 3H.5-13.

The tension ring is located at the interface of the shield building steel concrete composite air inlet structures and the shield building reinforced concrete roof. The top of the tension ring interfaces with the RC roof slab. The tension ring supports the roof girders that are located under the RC roof slab. The bottom of the tension ring is attached to the air inlets structure. The bottom of the air inlets structure is attached to the top of the cylindrical SC wall of the shield building. The connection of the tension ring to the roof is of RC design and is described above.

The primary function of the tension ring is to resist the thrust from the shield building roof. The air inlets structure is located directly below the tension ring and includes the air openings that provide for natural circulation of cooling air. Though its steel plates are connected to the concrete infill by studs and tie bars, the tension ring is conservatively designed as a hollow steel box girder. The concrete infill is credited only for out-of-plane shear transfer and for stability of the steel plates. The tension ring is designed to have high stiffness and to remain elastic under required load combinations.

The air inlets structure is a 4.5-foot-thick SC structure with through-wall openings for air flow. The air inlet openings consist of circular pipes at a downward inclination of 38 degrees from the vertical. Steel plates on each face, aligned with the inner and outer flanges of the tension ring, serve as primary reinforcement. The concrete infill is connected to the steel plates with tie bars and studs. The top of the air inlets structure is welded to the underside of the tension ring. The bottom of the air inlets structure is welded to the SC wall.

The shield building conical roof steel structure consists of 32 radial beams. Between each pair of radial beams there are circumferential beams. A steel plate is welded to the top flanges of each beam and forms a surface on which the concrete is placed. The steel structure forms a conical shell that spans the area from the compression ring to the tension ring.

The outside diameter of the PCS tank (passive containment cooling water storage tank) intersects with the shield building roof at the knuckle region. Outside of the PCS tank, the concrete roof slab thickness is 3 feet and at the bottom of the PCS tank, the concrete thickness is 2 feet. The wall from the PCS tank applies a load to the roof slab, and also provides stiffness and increases the strength of the roof in that region.

The inside diameter of the PCS tank intersects with the roof slab at the compression ring. The compression ring provides the compression support for the conical roof dome. It consists of a composite structure having a curved steel beam section, which supports the concrete roof directly above it. The inside wall of the PCS tank is located above the concrete roof. Studs are placed on the top flange of the steel girder to allow the steel and concrete sections to act as a composite unit. The curved girder is designed to provide support for the steel structure during construction and during the initial placement of the concrete roof before the concrete has hardened sufficiently.

The PCS tank sits on top of the shield building roof. It is supported by and acts integrally with the conical roof. The inside surface has a liner that functions to provide leak protection, but is not required to provide structural strength to the structure. Leak chase channels are provided over the liner welds. The top elevation of the water inside the tank for the PCS has sufficient freeboard to preclude impact on the roof during the SSE.

3H.3 Design Criteria

[*The auxiliary and shield building structures are reinforced concrete structures, structural modules, and horizontal concrete slabs supported by composite structural steel framing.*

- *Seismic forces are obtained from the response spectrum analysis of the three-dimensional finite element analysis models as described in subsection 3H.4. The shear wall and floor slab design also considers out-of-plane bending and shear forces due to loading, such as live load, dead load, seismic, lateral earth pressure, hydrostatic, hydrodynamic, and wind pressure.*
- *The shield building roof and the passive containment cooling water storage tank are analyzed using three-dimensional finite element models with the ANSYS computer code*]* as described in subsection 3.8.4.4.1. [*Loads and load combinations include construction, dead, live, thermal, wind, and seismic. The response spectrum analysis of the nuclear island is supplemented by equivalent static acceleration analysis of a more detailed model of a quadrant of the shield building roof. The results from the more detailed analysis are used in the evaluation of the tension ring, air inlets, and radial beams. The seismic response of the water in the tank is analyzed in a separate analysis with seismic input defined by the floor response spectrum.*
- *The structural steel framing is used primarily to support the concrete slabs and roofs. Metal decking, supported by the steel framing, is used as form work for the concrete slabs and roofs.*

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

H. Equipment laydown and major maintenance

Floors are designed for planned refueling and maintenance activities as defined on equipment laydown drawings.]*

Wind Load

[*The wind loads are as follows:*

- *Design wind (W)*

  For the design of the exterior walls, wind loads are applied in accordance with ASCE 7-98 with a basic wind speed of 145 mph. The importance factor is 1.15, and the exposure category is C. Wind loads are not combined with seismic loads.

- *Tornado load (W_t)*

  The exterior walls of the auxiliary and shield buildings are designed for tornado. A maximum wind speed of 300 mph (maximum rotational speed: 240 mph, maximum translational speed: 60 mph) is used to design the structures.]*

Seismic Loads (E_s)

[*The SSE (E_s) is used for evaluation of the structures of the auxiliary and shield buildings. E_s is defined as the loads generated by the SSE specified for the plant, including the associated hydrodynamic loads and dynamic incremental soil pressure.*]*

Operating Thermal Loads (T_o)

[*Normal thermal loads for the exterior walls and roofs are addressed in the design. These correspond to positive and negative linear temperature gradients with the inside surface at an average 70°F and the outside air temperature at -40°F and +115°F, respectively. These loads are considered for the seismic Category I structures in combination with the SSE also. All exterior walls of the nuclear island above grade not protected by adjacent buildings are designed for these thermal loads. The thermal gradient is also applied to the portion of the shield building between the upper annulus and the auxiliary building.*

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Normal thermal loads for the passive containment cooling system (PCS) tank design are calculated based on the outside air temperature extremes specified for the safety-related design. The PCS tank is assumed to be at 40°F when the outside air temperature is -40°F. The water in the PCS tank is assumed to be at 70°F when the outside air temperature is postulated to be at 115°F.

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Deleted: *With the water temperature in the tank assumed at +40°F, the positive and negative temperature gradients are determined for the outside surface at -40°F and +115°F respectively.*

Normal thermal loads due to a thermal gradient in the structures below the grade level (exterior walls and basemat) are small and are not considered in the design.]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

3H.4 Seismic Analyses

*[A global seismic analysis of the AP1000 nuclear island structure is performed to obtain building seismic response for the seismic design of nuclear safety-related structures. The seismic loads for the design of the shear walls and the slabs in the auxiliary building are based on a response spectrum analysis of the auxiliary building and the shield building 3D finite element models.]** This analysis is described in subsection 3.7.2. *[For determining the out-of-plane seismic loads on flexible slabs and wall segments, spectral accelerations are obtained from time history analyses or from the relevant response spectra, using the 7 percent damping curve. Hand calculations are performed to estimate the out-of-plane seismic forces and the corresponding bending moment in each shear wall and floor slab element to supplement the loads obtained from the global seismic analysis.]**

3H.4.1 Live Load for Seismic Design

[Floor live loads, based on requirements during plant construction and maintenance activities, are specified varying from 50 to 250 pounds per square foot.

*For the local design of members, such as the floors and beams, seismic loads include the response due to masses equal to 25 percent of the specified floor live loads or 75 percent of the roof snow load, whichever is applicable. These seismic loads are combined with 100 percent of the specified live loads, or 75 percent of the roof snow load, whichever is applicable. These live and snow loads are included as mass in calculating the vertical seismic forces on the floors and roof. The mass of equipment and distributed systems is included in both the dead and seismic loads.]**

3H.5 Structural Design of Critical Sections

[This subsection summarizes the structural design of representative seismic Category I structural elements in the auxiliary building and shield building. These structures are listed below and the corresponding location numbers are shown on Figure 3H.5-1. The basis for their selection to this list is also provided for each structure.

(1) South wall of auxiliary building (column line 1), elevation 66'-6" to elevation 180'-0". (This exterior wall illustrates typical loads such as soil pressure, surcharge, temperature gradients, seismic, and tornado.) – see subsection 3H.5.1.1 and Figures 3H.5-2 and 3H.5-3

(2) Interior wall of auxiliary building (column line 7.3), elevation 66'-6" to elevation 160'-6" (This is one of the most highly stressed shear walls.) – see subsection 3H.5.1.2 and Figure 3H.5-4

(3) West wall of main control room in auxiliary building (column line L), elevation 117'-6" to elevation 153'-0". (This illustrates design of a wall for subcompartment pressurization.) – see subsection 3H.5.1.3 and Figure 3H.5-12

(4) North wall of MSIV east compartment (column line 11 between column lines L and M), elevation 117'-6" to elevation 153'-0". (The main steam line is anchored to this wall segment.) – see subsection 3H.5.1.4 and Figure 3H.5-5

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

(5) *Roof slab at elevation 180'-0" adjacent to shield building cylinder. (This is the connection between the two buildings at the highest elevation.) – see subsection 3H.5.2.1 and Figure 3.H.5-7*

(6) *Floor slab on metal decking at elevation 135'-3". (This is a typical slab on metal decking and structural steel framing.) – see subsection 3H.5.2.2 and Figure 3H.5-6*

(7) *2'-0" slab in auxiliary building (operations work area (tagging room) ceiling) at elevation 135'-3". (This illustrates the design of a typical 2'-0" thick concrete slab.) – see subsection 3H.5.3.1 and Figure 3H.5-8. (Note: The 'Tagging Room' has been renamed as "Operations Work Area." However, to avoid changing the associated design and analysis documents, this room is referred to as the 'Tagging Room.')*

(8) *Finned floor in the main control room at elevation 135 -3". (This illustrates the design of the finned floors.) – see subsection 3H.5.4 and Figure 3H.5-9*

(9) *Shield building roof/exterior wall of PCS water storage tank. (This is a unique area of the roof and water tank.) – see subsection 3H.5.6.3*

(10) *Shield building roof/interior wall of PCS water storage tank. (This is a unique area of the roof and water tank.) – see subsection 3H.5.6.2*

(11) *Shield building roof, tension ring, and air inlet. (This is the junction between the shield building roof and the cylindrical wall of the shield building.) – see subsections 3H.5.6 and 3H.5.6.1*

(12) *Divider wall between the spent fuel pool and the fuel transfer canal. (This wall is subjected to thermal and seismic sloshing loads.) – see subsection 3H.5.5.1 and Figure 3H.5-10*

(13) *Shield building SC cylinder is the exposed portions of the shield building that are not protected by the Auxiliary Building and is a steel concrete composite structure – see subsection 3H.5.7.1, Figure 3H.5-16, and Figures 5 and 6 of APP-GW-GLR-602 (Reference 1)*

(14) *Shield building SC to RC connection is the region of the shield building that anchors the SC cylindrical wall modules to the RC basemat and wall of the shield building – see subsection 3H.5.7.2, Figure 3H.5-16, and Figures 1, 2, and 3 of APP-GW-GLR-602 (Reference 1)*

*The design implemented in fabrication and construction drawings and instructions will have the design shown, an equal design, or a better design for the key structural elements.]**

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Deleted: *(5) . Shield building cylinder, elevation 160'-6" to elevation 266'-3". (This includes the connection of the roof slab at elevation 180'-0" in (6) below.) – see subsection 3H.5.1.5 and Figure 3H.5-7¶*
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3H.5.1 Shear Walls

Structural Description

[Shear walls in the auxiliary building vary in size, configuration, aspect ratio, and amount of reinforcement. The stress levels in shear walls depend on these parameters and the seismic acceleration level. The range of these parameters and the stress levels in various regions of the most severely stressed shear wall are described in the following paragraphs.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

The height of the major structural shear walls in the auxiliary building ranges between 30 to 120 feet. The length ranges between 40 and 260 feet. The aspect ratio of these walls (full height/full length) is generally less than 1.0 and often less than 0.25. The walls are typically 2 to 5 feet thick, and are monolithically cast with the concrete floor slabs, which are 9 inches to 2 feet thick. Exterior shear walls are several stories high and do not have many large openings. Interior shear walls, however, are discontinuous in both vertical and horizontal directions. The in-plane behavior of these shear walls, including the large openings, is adequately represented in the analytical models for the global seismic response. Where the refinement of these finite element models is insufficient for design of the reinforcement, for example in walls with a large number of openings, detailed finite element models are used.

*The shear walls are used as the primary system for resisting the lateral loads, such as earthquakes. The auxiliary building shear walls are also evaluated for flexure and shear due to the out-of-plane loads.]**

Design Approach

[The auxiliary building shear walls are designed to withstand the loads specified in subsection 3H.3.3. Beside dead, live, and other normal operating condition loads, the following loads are considered in the shear wall design:

- *Seismic loads*
  - *The SSE loads for the wall are obtained from the seismic analyses of auxiliary/shield buildings that are described in subsection 3H.4.*
  - *Calculations are performed by considering shear wall segments bounded by the floors below and above the segment and the adjacent walls perpendicular to, on both sides of, the segment under consideration. Appropriate boundary conditions are assumed for the four edges of the segment. Natural frequencies of wall segments are determined using finite element models or text book formulas for the frequency of plate structures. Corresponding spectral acceleration is determined from the applicable response spectrum.*
  - *Exterior walls, below grade level, are also evaluated for dynamic earth pressure exerted during an SSE for two cases:*
    - *Dynamic earth pressure calculated in accordance with ASCE 4-98*
    - *Passive earth pressure*
- *Accident pressure load*
  - *Shear walls of the main steam isolation valves (MSIV) rooms are designed for 6 pounds per square inch (psi) differential pressure acting in conjunction with the seismic loads. Member forces due to accident pressure and SSE are combined by absolute sum.*
  - *The main control room wall of the east MSIV compartment is evaluated for the pressure and the jet load due to a postulated main steamline break.*

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

- *Tornado load*

  For exterior walls above grade level, tornado loads are considered.

The design temperatures for thermal gradient are included in Table 3H.5-1.

The shear walls are designed for the load combinations, as applicable, contained in Table 3.8.4-2. The wall sections are designed in accordance with the requirements of ACI 349-01.]*

3H.5.1.1 Exterior Wall at Column Line 1

[*The wall at column line 1 is the exterior wall at the south end of the nuclear island. The reinforced concrete wall extends from the top of the basemat at elevation 66'-6" to the roof at elevation 180'-0". It is 3'-0" thick below the grade and 2'-3" thick above the grade.*

The wall is designed for the applicable loads including dead load, live load, hydrostatic load, static and dynamic lateral soil pressure loads, seismic loads, and thermal loads. For various segments of this wall, Table 3H.5-2 provides the listing and magnitude of the various design loads and Table 3H.5-3 presents the details of the wall reinforcement. The sections where the required reinforcement is calculated are shown in Figure 3H.5-2 (Sheet 1). Typical wall reinforcement is shown on Figure 3H.5-3.]*

3H.5.1.2 Wall at Column Line 7.3

[*The wall at column line 7.3 is a shear wall that connects the shield building and the nuclear island exterior wall at column line I. It extends from the top of the basemat at elevation 66-6" to the top of the roof. The wall is 3 feet thick below the grade at elevation 100'-0" and 2 feet thick above the grade. Out-of-plane lateral support is provided to the wall by the floor slabs on either side of it and the roof at the top.*

The auxiliary building design loads are described in Section 3H.3.3, and the wall is designed for the applicable loads.

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For various segments of this wall, the corresponding governing load combination and associated design loads are shown in Table 3H.5-4. Table 3H.5-5 presents the details of the wall reinforcement. The sections where the required reinforcement is calculated are shown in Figure 3H.5-2 (Sheet 2). Typical wall reinforcement is shown on Figure 3H.5-4]*

3H.5.1.3 Wall at Column Line L

[*The wall at column line L is a shear wall on the west side of the Main Control Room. It extends from the top of the basemat at elevation 66-6" to the top of the roof. The wall is 2 feet thick. Out-of-plane lateral support is provided to the wall by the floor slabs on either side of it and the roof at the top. The segment of the wall that is a part of the main control room boundary is from elevation 117'-6" to elevation 135'-3".*

The auxiliary building design loads are described in subsection 3H.3.3, and the wall is designed for the applicable loads. In addition to the dead, live and seismic loads, the wall is designed to

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

withstand a 6 pounds per square inch pressure load due to a pipe break in the MSIV room even though it is a break exclusion area. This wall segment is also designed to withstand a jet load due to the pipe break.

The governing load combination and associated design loads are those due to the postulated pipe rupture and are shown in Table 3H.5-6. Table 3H.5-7 and Figure 3H.5-12 present the details of the wall reinforcement. The sections where the required reinforcement is calculated are shown in Figure 3H.5-2 (Sheet 3).]*

3H.5.1.4 Wall at Column Line 11

[*The north wall of the MSIV east compartment, at column line 11 between elevation 117'-6" and elevation 153'-0", has been identified as a critical section.*

The segment of the wall between elevation 117'-6" and elevation 135'-3" is 4 feet thick, and several pipes such as the main steam line, main feed water line, and the start-up feed water line are anchored to this wall at the interface with the turbine building.

The wall segment from elevation 135'-3" to elevation 153'-0" does not provide support to any high energy lines, and is 2 feet thick. This portion does not have to withstand reactions from high energy line breaks.

The wall is designed to withstand loads such as the dead load, live load, seismic load and the thermal load. The MSIV room is a break exclusion area, but the design also considered the loads associated with one square foot pipe rupture in the MSIV room, such as compartment pressurization, jet load, and the reactions at the pipe anchors. The loads on the pipe anchor include pipe rupture loads for breaks in the turbine building.

The wall structure is analyzed using three dimensional finite element analyses supplemented by hand calculations. Analyses are performed for individual loads, and design loads are determined for applicable load combinations from Table 3.8.4-2.

Typical wall reinforcement is shown in Figure 3H.5-5.]*

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[*The thickness of the cylindrical portion of the shield building wall is 3 feet. Below the air inlets region, the wall consists of high strength concrete contained within 0.75-inch-thick steel liner plates on both faces. The liner plates, tied to concrete with shear connectors, behave as reinforcement bars. The tie bars and studs are welded to the outside faces of the steel plates to develop a composite behavior of the steel face plates and concrete.¶*
The wall is designed for the applicable loads described in subsection 3H.3.3. A finite element analysis is performed to determine the design forces.¶
The design of the shield building roof is further described in 3H.5.6.]*¶

3H.5.2 Composite Structures (Floors and Roof)

[*The floors consist of a concrete slab on metal deck, which rests on structural steel floor beams. Several floors in the auxiliary building are designed as one-way reinforced concrete slabs supported continuously on steel beams. Typically, the beams span between two reinforced concrete walls. The beams are designed as composite with formed metal deck spanning perpendicular to the members. Unshored construction is used. For the floors, beams are typically spaced at about 6-feet intervals and spans are between 16 feet and 25 feet.*]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

3H.5.3 Reinforced Concrete Slabs

*[Reinforced concrete floors in auxiliary building are 24 inch or 36 inch thick. These floors are constructed with 16" or 28" of reinforced concrete placed on the top of 8 inch thick precast concrete panels. The 8" thick precast concrete panels are installed at the bottom to serve as the formwork and withstand the load of wet concrete slab. The main reinforcement is provided in the precast panels which are connected to the concrete placed above it by shear reinforcement. The precast panels and the cast-in-place concrete act together as a composite reinforced concrete slab. Examples of such floors are the Operations Work Area (Tagging Room) ceiling slab at elevation 135 ft 3 inches in Area 2, and the Area 5/6 elevation 100'-0" slab between column lines 1 & 2.]**

3H.5.3.1 Operations Work Area (Tagging Room) Ceiling

The tagging room (room number 12401) location is shown on Figure 1.2-8. *[Figure 3H.5-8 shows the typical cross section and reinforcement. The design summary is shown in Table 3.H.5-12. Design dimensions of the Operations Work Area (Tagging Room) Ceiling are as follows:*

Room Size:	*16'-0" x 11'-10"*
Boundary Conditions:	*Fixed at Walls J and K*
Clear Span:	*16'-0"*
Slab Thickness:	*Total = 24 inches* *Precast Panel = 8 inches* *Cast-in-Place = 16 inches*

*The two precast concrete panels, each 5 -11" wide and spanning over 16'-0" clear span, are installed to serve as the formwork.]**

3H.5.4 Concrete Finned Floors

[The ceilings of the main control room and the instrumentation and control rooms in the auxiliary building are designed as finned-floor modules. A typical floor design is shown in Figure 3H.5-9. A finned floor consists of a 24-inch-thick concrete slab poured over a stiffened steel plate ceiling. The fins, welded to stiffen the steel plate, are half inch by 9 inch rectangular sections perpendicular to the plate. Shear studs are welded on the other side of the steel plate, and the steel and concrete act as a composite section. The fins are exposed to the environment of the room and enhance the heat-absorbing capacity of the ceiling. Several shop-fabricated steel panels, cut to room width and placed side by side perpendicular to the room length, are used to construct the stiffened plate ceiling in a modularized fashion. The stiffened plate with fins is designed to withstand construction loads prior to concrete hardening.

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The main control room ceiling fin floor is designed for the dead, live, and the seismic loads. The design summary is shown in Table 3.H.5-13.

*The finned floor structure is evaluated for the load combinations listed in Tables 3.8.4-1 and 3.8.4-2.]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

internal structures (see description in subsection 3.8.3 and Figures 3.8.3-8, 3.8.3-14, 3.8.3-15 and 3.8.3-17). Figure 3.8.4-5 shows the location of the structural modules in the auxiliary building. The structural modules extend from elevation 66'-6" to elevation 135'-3".

The loads and load combinations applicable to the structural modules in the auxiliary building are the same as for the containment internal structures]* (subsection 3.8.3.5.3) [*except that there are no ADS nor pressure loads due to pipe breaks.*

The design methodology of these modules in the auxiliary building is similar to the design of the structural modules in the containment internal structures]* described in subsection 3.8.3.5.3.

3H.5.5.1 West Wall of Spent Fuel Pool

[*Figure 3H.5-10 shows an elevation of the west wall of the spent fuel pool (column line L-2), and element numbers in the finite element model. The wall is a 4 feet thick concrete filled structural wall module.*

A finite element analysis is performed for seismic, thermal, and hydrostatic loads with the following assumptions:

- *The seismic in-plane and out-of-plane forces are obtained from the response spectrum analysis of the 3D finite element model of the auxiliary and shield buildings.*
- *The thermal loads are applied as linearly varying temperatures between the inner and outer faces of the walls and floors.*
- *The hydrostatic loads are applied to the spent fuel pool walls and floors, which is considered full with water. This provides the loads for the design of the divider wall.*
- *The seismic sloshing is modeled in the spent fuel pool.*

The concrete filled structural wall modules are designed as reinforced concrete structures in accordance with the requirements of ACI-349. The face plates are treated as reinforcing steel.

Methods of analysis are based on accepted principles of structural mechanics and are consistent with the geometry and boundary conditions of the structures. Both computer codes and hand calculations are used.

Table 3H.5-8 shows the required plate thickness for certain critical locations. The steel plates are half inch thick.]*

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

3H.5.6 Shield Building Roof and Connections

[The shield building roof is a reinforced concrete shell (supporting the passive containment cooling system tank and air diffuser), which is supported on a structural steel module. The structural configuration is shown on sheets 7, 8, and 9 of Figure 3.7.2-12. Air intakes are located at the top of the cylindrical portion of the shield building. The conical roof supports the passive containment cooling system tank. The conical roof is constructed as a structural steel module and lifted into place during construction. Steel beams provide permanent structural support for steel liner and concrete. The concrete is cast in place. Connection between concrete and steel liner are made using shear studs.

The design of the shield building is shown in Figure 3H.5-11 (Sheets 1-6). These figures show the typical details of the "Tension Ring," the "Air Inlet Structure," and the "Exterior Wall of the Passive Containment Cooling System Tank." Figure 3H.5-16, Sheets 1 and 2, also shows the typical dimensions of the surface plates and the SC to RC connections on the shield building cylindrical segment.

A detailed ANSYS model was used to represent these components of the enhanced design. Analyses were performed to determine the response of the structures for the dead weight, hydrostatic load due to PCS water, snow load, wind load, tornado load, seismic load (including seismic-induced pressure on PCS wall), and thermal loads. The design was evaluated to comply with the requirements of ANSI/AISC N690-94 and of ACI 349-01.

The design summaries of the components are included in Table 3H.5-9.

The steel frame for the shield building roof and the concrete placed directly thereon is designed to AISC N690.

- *In the radial direction, the steel beams, the steel surface plate, and the concrete are evaluated as a composite section using the axial and bending member forces in the steel and concrete section from the finite element analyses. The steel stresses and the end connection are calculated assuming the steel alone resists all loads applied before the concrete has reached 75 percent of its required strength and the effective composite section resists all loads applied after that time.*
- *The concrete is evaluated using all member forces in the concrete and surface steel plate from the finite element analyses (in-plane and out-of-plane forces and moments). The circumferential channels are provided for construction only and are not modeled in the finite element analysis or credited for resisting permanent loads. The concrete section is evaluated by the strength method of ACI-349. The steel plate is not considered as reinforcement in the circumferential direction.*

*Additional information is provided in Table 3H.5-15.]**

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Deleted: 3H.5.6.1 Reinforced Concrete (RC)/Steel Concrete Composite (SC) Horizontal and Vertical Connections¶
[*The steel plate modules are anchored to the RC basemat and walls of the shield building by mechanical rebar connections. The connectors provide for the direct transfer of forces from the RC reinforcing steel to the SC liner plates.*¶
At the horizontal connection at the interface with the RC structure that occurs on the bottom of the lowest SC wall module, each vertical reinforcing bar in the RC basemat wall is connected to a mechanical coupler. A similar vertical connection occurs on the vertical edges of SC wall modules that interface with the RC portion of the shield building wall. In the vertical connection, each hoop reinforcing bar in the RC wall is connected to a mechanical coupler and forces are transferred directly from the hoop bars to the SC liner plate. The mechanical connections are designed to the stress limits of ANSI/AISC N690 for loads in the reinforcing bars equivalent to 125 percent of the yield strength of the reinforcing bars and are proven components used in existing structures. This connection improves the overall ductility of the RC/SC connection.]*¶
3H.5.6.2 Shield Building Cylindrical Wall¶
[*The shield building surrounds the containment vessel and shares a common basemat with the containment vessel and the auxiliary building. The cylindrical shield wall has an outside radius of 72.5 feet and a thickness of 36 inches. The cylindrical wall section that is below the auxiliary building roof line is a reinforced concrete structure. The section that is not protected by the auxiliary building is a steel concrete composite structure, where two 0.75-inch plates act compositely with 34.5 inches of concrete via tie bars and shear studs. The steel plate modules are connected to the reinforced concrete basemat and walls by mechanical connectors as described above.*¶
A typical configuration of the SC wall is shown in Figure 3H.5-13. The overall thickness of 36 inches is the same as the RC wall below. The concrete for the SC portion is standard concrete with a compressive strength of 6000 psi. The SC portion is constructed with steel surface plates, which act as concrete reinforcement. The nominal thickness of the steel faceplates is 0.75 inches. In each module, tie bars ...

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

3H.5.6.1 Air Inlets and Tension Ring

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[The configuration and plate size of the air inlets enhance their structural performance. The air inlets structure (as shown on Figure 3H.5-14) is located at the top of the cylindrical wall portion of the shield building, beginning at approximately elevation 251' and rising to approximately elevation 266'. The air inlets serve as the intake for air as part of the PCS.

Above the air inlets, at approximately elevation 266', is the connection designated as the tension ring that connects and supports the conical roof. The tension ring also contains 32 radial beam seat connections where the W36 x 393 radial beams for the conical roof are connected.

The air inlets region is 4.5-feet thick with steel plates on each face as the primary reinforcement, which are connected using tie bars. Near the bottom of the air inlet structure, the thickness transitions to 3 feet thick to connect with the shield building cylinder. The air inlet openings are formed using pipe at a downward inclination of 38 degrees from the vertical. The pipe spacing is approximately 2.81 degrees circumferentially with shear studs welded to the outside surface of the pipes. The tie bars are located with three bars between adjacent air inlets at each elevation at maximum design spacing of 8.5 inches vertically. At approximately the same elevations as the tie bars, two 3/4-inch by 6-inch (minimum) shear studs are located between the tie bars except at elevations where there is interference with the air inlet pipes. Tie bars and studs may be omitted in local areas due to design features and other obstructions.

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*The tension ring is designed as a structural steel box structure with concrete infill and shear studs. Also the connection of the RC conical roof to the tension ring is designed to be a mechanical connection. The air inlets and tension ring design methodology is supported by linear analysis and benchmarked nonlinear analysis. The tension ring is designed to ANSI/AISC N690 and is a concrete-filled box girder, with two continuous 1.5-inch-thick steel plates top and bottom, which connect the inner liner plate to the outer liner plate, as shown in Figure 3H.5-15.]**

3H.5.6.2 Compression Ring and Interior Wall of Passive Containment Cooling Water Storage Tank

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Deleted: , Knuckle Region,

[The other areas of the shield building are designed to existing industry code requirements, and include the conical roof, the passive containment cooling water storage tank, the compression ring, the knuckle region, and their related attachments. These areas are designed as RC structures in accordance with ACI 349. The steel frame for the roof is designed for the applicable building code ANSI/AISC N690. The concrete roof is designed to ACI 349 requirements without credit for the steel plate on the bottom of the concrete. The configuration and reinforcement of the compression ring and the connection to the interior wall of the passive containment cooling water storage tank is shown in Figure 3H.5-11.

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*Additional information is provided in Table 3H.5-15.]**

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3H.5.6.3 Knuckle Region and Exterior Wall of Passive Containment Cooling System Tank

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[The exterior wall of the passive containment cooling system tank is two feet thick. The wall starts at the tank floor elevation of 293' 9". There is a stainless steel liner on the inside surface of the tank. The wall liner consists of a plate with stiffeners and welded studs on the concrete side of the

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

plate. Leak chase channels are provided over the liner welds. The reinforcement in the concrete wall is designed without taking credit for the strength provided by the liner. The governing loads for design of the exterior wall are the hydrostatic pressure of the water, the in-plane and out-of-plane seismic response, and the temperature gradient across the wall. The reinforcement is shown in Figure 3H.5-11. The reinforcement required and the reinforcement provided is summarized in Table 3H.5-9.

*Additional information is provided in Table 3H.5-15.]**

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3H.5.7 Shield Building Cylinder (SC)

Comment [tlw50]: 9

3H.5.7.1 Shield Building Cylindrical Wall

[The shield building surrounds the containment vessel and shares a common basemat with the containment vessel and the auxiliary building. The cylindrical shield wall has an outside radius of 72.5 feet and a thickness of 36 inches. The cylindrical wall section that is below the auxiliary building roof line is a reinforced concrete structure. The section that is not protected by the auxiliary building is a steel concrete composite structure, where two 0.75-inch plates act compositely with 34.5 inches of concrete via tie bars and shear studs. The steel plate modules are connected to the reinforced concrete basemat and walls by mechanical connectors as described below.

A typical configuration of the SC wall is shown in Figure 3H.5-13. The overall thickness of 36 inches is the same as the RC wall below. The concrete for the SC portion is standard concrete with a compressive strength of 6000 psi. The SC portion is constructed with steel surface plates, which act as concrete reinforcement. The nominal thickness of the steel faceplates is 0.75 inches. In each module, tie bars are welded to the steel faceplates to develop composite behavior of the steel faceplates and concrete. The shear studs are welded to the inside surface of the steel plate to provide composite action. The tie bars are at closer spacing in the higher stress regions. The reinforcement detailing incorporates ACI 349 requirements.

The panels of the SC wall are welded together with a complete joint penetration weld.

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The wall is designed for the applicable loads described in subsection 3H.3.3. A finite element analysis is performed to determine the design forces.

Table 3H.5-14 shows the design summary for the enhanced shield SC cylindrical wall. The three sheets represent locations in the shield building cylinder that have some of the largest demands due to mechanical loads. The element on the west side at grade near the RC/SC connection has large tension forces due to overturning of the cylinder under seismic demand. This area is one of the most stressed elements in tension. The element near the fuel handling building roof at elevation 180' is an element with high out-of-plane shear due to the interaction between the fuel handling building and the cylinder during an earthquake. This element is located close to the fuel building roof. The element above wall 7.3 at elevation 175' has the largest demand for out-of-plane shear in the general part of the cylindrical wall away from the SC/RC connection and the interface with the auxiliary building roof.

*Additional discussion and information are provided in Section 4 and Figures 5 and 6 of APP-GW-GLR-602 (Reference 1).]**

Comment [rmk52]: 9

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

3H.5.7.2 Reinforced Concrete (RC)/Steel Concrete Composite (SC) Horizontal and Vertical Connections

[The steel plate modules are anchored to the RC basemat and walls of the shield building by mechanical rebar connections. The connectors provide for the direct transfer of forces from the RC reinforcing steel to the SC liner plates.

At the horizontal connection at the interface with the RC structure that occurs on the bottom of the lowest SC wall module, each vertical reinforcing bar in the RC basemat wall is connected to a mechanical coupler. A similar vertical connection occurs on the vertical edges of SC wall modules that interface with the RC portion of the shield building wall. In the vertical connection, each hoop reinforcing bar in the RC wall is connected to a mechanical coupler and forces are transferred directly from the hoop bars to the SC liner plate. The mechanical connections are designed to the stress limits of ANSI/AISC N690 for loads in the reinforcing bars equivalent to 125 percent of the specified yield strength of the weaker of the steel plate or reinforcing bar and are proven components used in existing structures. This design basis exceeds the maximum demand that occurs on the west side of the shield building at grade and is summarized in Sheet 3 of Table 3H.5-14. This connection improves the overall ductility of the RC/SC connection.

*Additional discussion and information are provided in Section 4 and Figures 1, 2, 3, and 4 of APP-GW-GLR-602 (Reference 1).]**

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3H.5.8 References

1. *[APP-GW-GLR-602, Revision 1 (Proprietary) and APP-GW-GLR-603, Revision 1 (Non-Proprietary), "AP1000 Shield Building Design Details for Select Wall and RC/SC Connections," Westinghouse Electric Company LLC.]**

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-1

NUCLEAR ISLAND: DESIGN TEMPERATURES FOR THERMAL GRADIENT

Structure (See detail in Section 3H.3.3.)	**Load**	**Temperature (°F)**		**Remark**
PCS Tank Walls	Normal Thermal, T_o	[*(Outside)* *-40* *+115*	*(Inside)* *+40* +*70*]*	–
Roofs and Exterior Walls Above Grade Air Temperatures	Normal Thermal, T_o Accident Thermal, T_a	[*(Outside)* *-40* *+115* *-40* *-40*	*(Inside)* *+70* *+70* *+132* *+212*]*	– MSIV room Fuel handling area
Roofs and Exterior Walls Above Grade Concrete Temperatures	Normal Thermal, T_o Accident Thermal, T_a	[*(Outside)* *-21.6* *-22.8* *-25.4* *+3.2* *+109.1* *+108.0* *+107.5* *+98.6* *-40* *-40* *+63*	*(Inside)* *+47* *+48.4* *+51.5* *+46.6* *+79.2* *+80.7* *+81.3* *+81.3* *+132* *+212* *+212*]*	24″ thickness 27″ thickness 36″ thickness 15″ insulated roof 24″ thickness 27″ thickness 36″ thickness 15″ insulated roof MSIV room Fuel handling area Insulated roof
Interior Walls/Slabs Concrete Temperatures	Normal Thermal, T_o Accident Thermal, T_a	[*(Side 1)* *N/R* *+70* *+70*	*(Side 2)* *N/R* *+132* *+212*]*	– MSIV room Fuel handling area
Exterior Walls Below Grade	Normal Thermal, T_o Accident Thermal, T_a	N/R N/R	N/R N/R	– –
Basemat	Normal Thermal, T_o Accident Thermal, T_a	N/R N/R	N/R N/R	– –
Shield Building (Between Upper Annulus and Auxiliary Building)	Normal Thermal, T_o Accident Thermal, T_a	[*(Outside)* *-40* *+115* *-40* *N/R*	*(Inside)* *+70* *+70* *+132* *N/R*]*	– MSIV room wall Rest of wall

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Notes:

1. N/R means loads due to a thermal gradient are not required to be considered.
2. Based on ACI 349-01 (Appendix A), the base temperature for the construction is assumed to be 70°F.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-3

EXTERIOR WALL ON COLUMN LINE 1
DETAILS OF WALL REINFORCEMENT (in^2/ft)

(See Figure 3H.5-2 for Locations of Wall Sections.)

Wall Segment (See detail in subsection 3H.5.1.1.)	Location	Required(1)			*[Provided (Minimum)]**		
		Vertical	Horizontal	Shear	*Vertical*	*Horizontal*	*Shear*
Wall Section 1, 6							
Elevation 180′-0″ to 135′-3″				NR			None
	Outside Face	3.48	2.65		*[3.91*	*3.12*	
	Inside Face	1.94	1.52		*3.12*	*3.12]**	
Wall Section 2, 3, 7							
Elevation 135′-3″ to 100′-0″				NR			None
	Outside Face	1.88	3.04		*[3.12*	*3.12*	
	Inside Face	1.77	2.23		*3.12*	*3.12]**	
Wall Section 4, 8							
Elevation 100′-0″ to 82′-6″				0.003			*[0.44]**
	Outside Face	1.42	0.70		*[3.12*	*1.56*	
	Inside Face	1.01	0.70		*3.12*	*1.27]**	
Wall Section 5, 9							
Elevation 82′-6″ to 66′-6″				0.27			*[1.00]**
	Outside Face	2.29	0.87		*[4.39*	*1.27*	
	Inside Face	1.87	0.87		*3.12*	*1.27]**	

Notes:
1. NR = not required.
2. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-5

INTERIOR WALL ON COLUMN LINE 7.3
DETAILS OF WALL REINFORCEMENT

(See Figure 3H.5-2 for Locations of Wall Sections.)

Wall Segment (See detail in subsection 3H.5.1.2.)	Location	Wall Section	Reinforcement on Each Face (in²/ft)	
			Required[(1)]	[*Provided (Min.)*]*
From Roof to Elevation 155′-6″	Horizontal	1	3.96	[*4.12*
	Vertical	7	3.60	*3.72*
Elevation 155′-6″ to 135′-3″	Horizontal	2	2.80	*3.12*
	Vertical	8	3.59	*3.72*
Elevation 135′-3″ to 117′-6″	Horizontal	3	2.03	*2.54*
	Vertical	9	2.63	*3.12*
Elevation 117′-6″ to 100′-0″	Horizontal	4	2.29	*2.54*
	Vertical	10	2.98	*3.12*
Elevation 100′-0″ to 82′-6″	Horizontal	5	1.69	*2.54*
	Vertical	11	2.08	*3.12*
Elevation 82′-6″ to 66′-6″	Horizontal	6	0.85	*1.27*
	Vertical	12	0.98	*1.56*
Shear Reinforcement (in²/ft²)				
From Roof to Elevation 155′-6″	Standard hook or T headed bar	7	0.38	*0.44*]*

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Note:

1. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-7

INTERIOR WALL ON COLUMN LINE L
DETAILS OF WALL REINFORCEMENT

(See Figure 3H.5-2, Sheet 3, for Locations of Wall Sections.)

Wall Segment (See detail in subsection 3H.5.1.3.)	Location	Wall Section	Reinforcement on Each Face (in^2/ft^2) Required(1)	[Provided (Min.)]*
Elevation 154′-2″ to 135′-3″	Horizontal	1	2.08	*[2.27*
	Vertical	3	2.59	*3.12*
Elevation 135′-3″ to 117′-6″	Horizontal	2	1.36	*4.39*
	Vertical	4	2.02	*5.66]**
Shear Reinforcement (in^2/ft^2)				
Elevation 154′-2″ to 135′-3″	Standard hook or T headed bar	5	0.01	*[0.11*
Elevation 135′-3″ to 117′-6″	Standard hook or T headed bar	6	0.33	*2.00]**

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Note:

1. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-9 (Sheet 1 of 3)

SHIELD BUILDING ROOF REINFORCEMENT SUMMARY (TENSION RING)

Tension Ring – Axial Force and Bending Verification

Location		Seismic Maximum Stresses		Maximum Stresses ksi	F_y ksi	Maximum Steel Area Required[(2)] (in^2/ft)	[Steel Area Provided]*	[Design Limit[(1)] for Ratio Max Required/ Provided]*
Section	**Angles**	**Seismic L/C**	**f_a ksi**					
2 lower	5.625°	9	14.31	14.31	50	7.74	[Liner 1 1/2" = 18 (in^2/ft) (Min)]*	[0.43 + 2%]*
	84.375°	17	12.52					
1 lower	0°	9	12.97					
	90°	17	11.39					

Tension Ring – Shear Force and Torsion Verification

Location		Seismic Maximum Stresses		Maximum Stresses ksi	F_y ksi	Maximum Steel Area Required[(2)] (in^2/ft)	[Steel Area Provided]*	[Design Limit for Ratio Max Required/ Provided]*
Section	**Angles**	**Seismic L/C**	**f_v ksi**					
2 lower	5.625°	17	4.83	5.52	50	5.04	[Liner 1 1/2" = 18 (in^2/ft) (Min.)]*	[0.28 + 2%]*
	84.375°	9	5.52					
1 lower	0°	18	3.20					
	90°	11	4.00					

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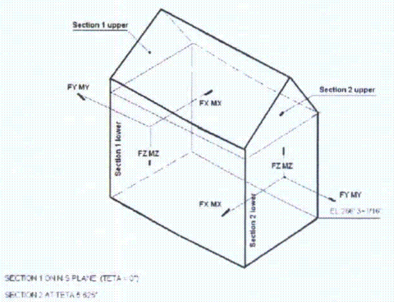

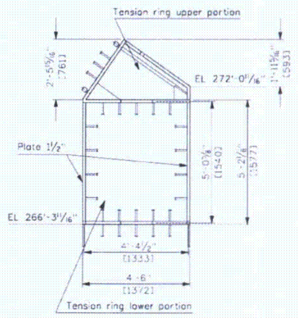

Notes:

1. [*Two percent of the value may be added to the design limit as an allowance for minor variances in analysis results.*]*
2. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-9 (Sheet 2a of 3) SHIELD BUILDING ROOF REINFORCEMENT SUMMARY (AIR INLET)						
AIS Reinforcement Summary – Horizontal Sections						
Locations (Figure 3H.5-11)		**Steel Area (Vertical Direction – Z Local Dir.)**				
		Required - Seismic Load Combinations (in²/ft)		**Maximum Required (in²/ft)**		***[Design Limit(1) for Ratio Max Required/ Provided]****
Sections	**Angles**	**Seismic L/C**	**Values**		*[Provided]**	
5+6	0°-5.625°	16	1.65	2.10	*[Liner 1" = 12 (in²/ft) (Min.)]**	*[0.175 + 2%]**
	84.375°-90°	8	1.41			
8	0°-5.625°	16	2.10			
	84.375°-90°	8	1.69			
9	0°-5.625°	16	2.10			
	84.375°-90°	8	1.68			
11	0°-5.625°	16	1.61	1.61	*[Liner 3/4" = 9 (in²/ft) (Min.)]**	*[0.18 + 2%]**
	84.375°-90°	24	1.21			

Notes:

1. *[Two percent of the value may be added to the design limit as an allowance for minor variances in analysis results.]**
2. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-9 (Sheet 2b of 3)

SHIELD BUILDING ROOF REINFORCEMENT SUMMARY (AIR INLET)

AIS Reinforcement Summary – Vertical Sections						
Locations (Figure 3H.5-11)		Steel Area (Hoop Direction – Y Local Dir.)				
Sections	Angles	Required - Seismic Load Combinations (in^2/ft) Seismic L/C	Values	Maximum Required[2] (in^2/ft)	[Provided]*	[Design Limit[1] for Ratio Max Required/ Provided]*
3 Upper	0°	9	9.56	10.04	[Liner 1" = 12 (in^2/ft) (Min.)]*	[0.84 + 2%]*
	90°	17	8.32			
3 Lower	0°	9	8.14			
	90°	18	7.03			
4 Upper	5.625°	9	10.04			
	84.375°	17	8.69			
4 Lower	5.625°	9	7.98			
	84.375°	19	6.82			

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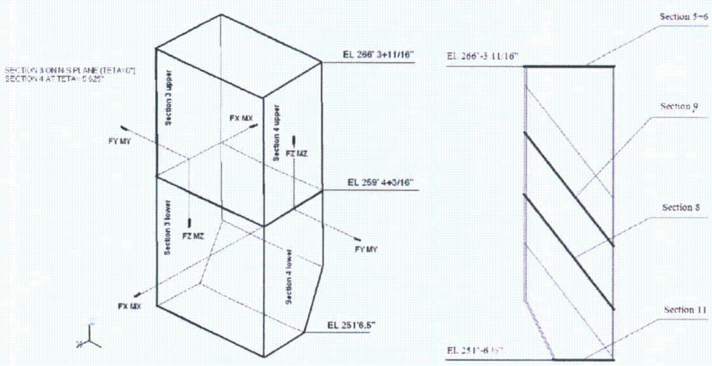

Notes:

1. [Two percent of the value may be added to the design limit as an allowance for minor variances in analysis results.]*
2. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-9 (Sheet 2c of 3)

SHIELD BUILDING ROOF REINFORCEMENT SUMMARY (AIR INLET)

Out of Plane Shear Reinforcement Summary – AIS

Locations (Figure 3H.5-11)		Required – Seismic Load Combinations (in²/ft)			Maximum Required(2) (in²/ft)	[Steel Area Provided]*	[Design Limit(1) for Ratio Max Required/ Provided]*
Angles	**Sections**	**Seismic L/C**	**Values**	**Sum**			
0° - 5.625°	Max of Vertical Sections 3 upper - 4 upper	1	0.10	0.10	0.34	[3 #6 TIE BAR @2.8125° (41.36") (8 1/2" in vertical direction) = 0.54 (in²/ft) (Min.)]*	[0.63 + 2%]*
	Horizontal Section 5+6		0.00				
84.375° - 90°	Max of Vertical sections 3 upper - 4 upper	1	0.10	0.10			
	Horizontal Section 5+6		0.00				
0° - 5.625°	Max of Vertical Sections 3 upper – 4 upper	9	0.10	0.34			
	Horizontal Section 8		0.24				
84.375° - 90°	Max of Vertical Sections 3 upper – 4 upper	1	0.10	0.30			
	Horizontal Section 8		0.20				
0° - 5.625°	Max of Vertical Sections 3 lower - 4 lower	0	0.093	0.22			
	Horizontal Section 9		0.127				
84.375° - 90°	Max of Vertical Sections 3 lower - 4 lower	0	0.183	0.18			
	Horizontal Section 9		0.000				
0° - 5.625°	Max of Vertical Sections 3 lower - 4 lower	1	0.167	0.17			
	Horizontal Section 11		0.000				
84.375° - 90°	Max of Vertical Sections 3 lower - 4 lower	0	0.02	0.02			
	Horizontal Section 11		0.00				

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Notes:

1. [Two percent of the value may be added to the design limit as an allowance for minor variances in analysis results.]*
2. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-9 (Sheet 3 of 3)

SHIELD BUILDING ROOF REINFORCEMENT SUMMARY (EXTERIOR WALL OF PASSIVE CONTAINMENT COOLING SYSTEM TANK)

Wall Segment	Location (Figure 3H.5-11 Sheet 5 of 6)	Reinforcement on Each Face, in²/ft Maximum Required	Provided (Minimum)		Ratio Required/ Provided
Bottom	Vertical	1.37	1#11@1.2°	[1.72	0.80
	Hoop	0.67	1#9@6"	2	0.33
	Shear	0.07	1#6@1.2°x12"	0.48	0.15
Mid-height	Vertical	0.64	1#11@1.2°	1.72	0.37
	Hoop	1.85	1#9@6"	2	0.92
Top	Vertical	0.52	1#11@1.2°	1.72	0.30
	Hoop	0.79	1#9@6"	2]*	0.39

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*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-10

DESIGN SUMMARY OF ROOF AT ELEVATION 180′-0″, AREA 6 (NEAR SHIELD BUILDING INTERFACE)

Governing Load Combination (Roof Girder)	
Combination Number	3 – Extreme Environmental Condition Downward Seismic Acceleration
Bending Moment	= 7125 kips-ft
Corresponding Stress	= 24.1 ksi
Allowable Stress	= 38.0 ksi
Shear Force	= 447 kips
Corresponding Stress	= 17.0 ksi
Allowable Stress	= 20.1 ksi
Governing Load Combination (Concrete Slab)	
Parallel to Girders	
Combination Numbers	3 – Extreme Environmental Condition
Reinforcement (Each Face)	
Required[1]	= 1.74 in^2/ft
[Provided	*= 2.54 in^2/ft (Minimum)]**
Perpendicular to Girders	
Combination Numbers	3 – Extreme Environmental Condition
Reinforcement (Each Face)	
Required[1]	= 1.68 in^2/ft
[Provided	*= 3.12 in^2/ft (Minimum)]**

Comment [tlw97]: 37

Comment [tlw98]: 37

Comment [tlw99]: 37

Note:

1. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-11

DESIGN SUMMARY OF FLOOR AT ELEVATION 135′-3″ AREA 1 (BETWEEN COLUMN LINES M AND P)

Governing Load Combination (Steel Beam)	
Load Combination	3 – Extreme Environmental Condition Downward Seismic
Bending Moment	=(-) 63.9 kips-ft
Corresponding Stress	= 17.0 ksi
Allowable Stress	=33.26 ksi
Shear Force	= 30.7 kips
Corresponding Stress	= 8.7 ksi
Allowable Stress	= 20.1 ksi
Governing Load Combination (Concrete Slab)	
Parallel to the Beams	
Load Combination	3 – Extreme Environmental Condition Downward Seismic
Bending Moment	=(-) 16.0 kips-ft/ft
In-plane Shear	=20.0 kips (per foot width of the slab)
Reinforcement (Each Face)	
Required[(1)]	= 0.41 in^2/ft
[Provided	*= 0.44 in^2/ft (Min.)]**
Perpendicular to the Beams	
Combination Number	Normal Condition
Bending Moment	=(+) 6.66 kips-ft (per foot width of the slab)
Reinforcement (Each Face)	
Required[(1)]	= 0.28 in^2/ft
[Provided	*= 0.60 in^2/ft (Min.)]**

Comment [tlw100]: 37

Comment [tlw101]: 37

Comment [tlw102]: 37

Note:

1. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-12

DESIGN SUMMARY OF FLOOR AT ELEVATION 135′-3″ (OPERATIONS WORK AREA (PREVIOUSLY KNOWN AS 'TAGGING ROOM') CEILING))

Design of Precast Concrete Panels	
Governing Load Combination	Construction
Design Bending Moment (Midspan)	= 14.53 kip-ft/ft
Bottom Reinforcement (E/W Direction)	
Required(1)	= 0.58 in^2/ft
[Provided	*= 0.79 in^2/ft (Min.)]**
Top Reinforcement (E/W Direction)	
Required(1)	= (Minimum required by Code)
[Provided	*= 0.20 in^2/ft (Min.)]**
Top and Bottom Reinforcement (N/S Direction)	
Required(1)	= (Minimum required by Code)
[Provided	*= 0.20 in^2/ft (Min.)]**
Design of 24-inch-Thick Slab	
Governing Load Combination	Extreme Environmental Condition (SSE)
Design Bending Moment (E/W Direction) Midspan	= 14.40 kips ft/ft
Design In-plane Shear	= 31.9 kips ft
Design In-plane Tension	= 21.9 kips ft
Bottom Reinforcement (E/W Direction)	
Required(1)	= 0.53 in^2/ft
[Provided	*= 0.79 in^2/ft (Min.)]**
Design Bending Moment (E/W Direction) at Support	= 28.81 kips-ft/ft
Design In-plane Shear	= 31.9 kips/ft
Design In-plane Tension	= 21.9 kips/ft
Top Reinforcement (E/W Direction)	
Required(1)	= 0.93 in^2/ft
[Provided	*= 1.00 in^2/ft (Min.)]**
Design Bending Moment (N/S Direction)	= 8.47 kips ft/ft
Design In-plane Shear	= 31.9 kips/ft
Design In-plane Tension	= 27.2 kip/ ft
Top and Bottom Reinforcement (N/S Direction)	
Required(1)	= 0.59 in^2/ft
[Provided	*= 0.79 in^2/ft (Min.)]**

Note:

1. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Comment [tlw103]: 37
Comment [tlw104]: 37
Comment [tlw105]: 37
Comment [tlw106]: 37
Comment [tlw107]: 37
Comment [tlw108]: 37
Comment [tlw109]: 37

Table 3H.5-13 **DESIGN SUMMARY OF FLOOR AT ELEVATION 135′-3″ AREA 1 (MAIN CONTROL ROOM CEILING)**
The design of the bottom plate with fins is governed by the construction load.
For the composite floor, the design forces used for the evaluation of a typical 9-inch-wide strip of the slab are as follows: Maximum bending moment = +35.0 (-24.4) kips-ft Maximum shear force = 22.3 kips
The design evaluation results are summarized below: (1) • [*The actual area of the tension steel is 9.0 in² (Min.),*]* which provides a design strength of 518.5 kips-ft bending moment capacity. • [*The design shear strength is 23.22 kips* • *The shear studs are spaced a maximum of 9 inches c/c, in both directions*.]* The calculated required spacing is 9.06 inches.

Note:
1. Thermal loads have been considered in the design of critical sections. The required reinforcement values shown do not include the load case where seismic and normal thermal loads are numerically combined as the normal thermal loads were assessed to be insignificant. When the seismic and normal thermal loads are numerically combined, the value of required reinforcement may increase; however, in all cases the required reinforcement is less than the provided reinforcement and thus the design of the critical section reinforcement is acceptable.

Comment [tlw110]: 37
Comment [rmk111]: 9
Comment [rmk112]: 9
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Comment [tlw113]: 37

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-14 (Sheet 1 of 3)

Comment [rmk114]: 9

DESIGN SUMMARY OF ENHANCED SHIELD BUILDING CYLINDRICAL WALL LOAD COMBINATIONS, AND COMPARISON TO ACCEPTANCE CRITERIA ELEVATION 180 FEET NEAR FUEL HANDLING BUILDING ROOF

Load/Combination	TX kip/ft	TY kip/ft	TXY kip/ft	MX k-ft/ft	MY k-ft/ft	MXY k-ft/ft	NX kip/ft	NY kip/ft	Comments
Dead	-6	-118	15	-25	-17	4	-6	-5	
Live	1	-1	0	0	0	0	0	0	
Seismic	155	385	163	299	209	35	71	33	
1	-7	-167	22	-35	-24	5	-8	-7	1.4 D + 1.7 L
2	150	266	179	274	192	38	65	28	D + L + Es
3	150	266	-147	-324	-226	-31	-76	-38	D + L + E's
4	-160	-504	-147	-324	-226	-31	-76	-38	D + L - Es
5	-160	-504	179	274	192	38	65	28	D + L - E's
6	150	278	177	277	193	38	66	28	0.9 D + Es
7	150	278	-149	-322	-224	-31	-76	-37	0.9 D + E's
35(2)	211	369	229	453	294	64	105	33	0.9 D + E's + αTo(W1)
37(2)	226	357	234	463	302	64	108	33	0.9 D + E's + αTo(W2)

Comment [tlw115]: 37
Comment [h116]: 37
Comment [tlw117]: 37
Comment [h118]: 37
Comment [tlw119]: 37

x-direction is horizontal; y-direction is vertical.

Element number: 12164

[Plate thickness required for load combinations excluding thermal: *0.43 inches + 2%(1)]**

[Plate thickness required for load combinations including thermal: *0.57 inches + 2%(1)]**

[Plate thickness provided: *0.75 inches]**

[Shear reinforcement required for load combinations excluding thermal: *0.64 in²/ft² + 2%(1)]**

[Shear reinforcement required for load combinations including thermal: *0.93 in²/ft² + 2%(1)]**

Shear reinforcement provided: See *[APP-GW-GLR-602, Section 4]**

Comment [tlw120]: 37
Comment [tlw121]: 9
Comment [tlw122]: 37
Comment [tlw123]: 9

Notes:

1. *[The Tier 2* designation for "Plate thickness required" requires NRC approval if this value is exceeded as a result of design changes or detail design adjustments identified during preparation of fabrication or construction drawings or instructions.]**
2. Load cases 35 and 37 are the two governing load combinations for element 12164 that include thermal and seismic loads combined numerically. W1 designates the winter conditions with the spent fuel pool at the normal operating temperature limit. W2 designates the winter conditions with the spent fuel pool and fuel transfer canal at the normal operating temperature limit. Es is SRSS (member forces are positive) of the SSE loads. E's is Es with all member forces except axial forces (TX, TY) reversed to negative.

Comment [h124]: 37

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-14 (Sheet 2 of 3)

DESIGN SUMMARY OF ENHANCED SHIELD BUILDING LOAD COMBINATIONS, AND COMPARISON TO ACCEPTANCE CRITERIA ELEVATION 175 FEET NEAR INTERSECTION WITH WALL 7.3

Load/Combination	TX kip/ft	TY kip/ft	TXY kip/ft	MX k-ft/ft	MY k-ft/ft	MXY k-ft/ft	NX kip/ft	NY kip/ft	Comments
Dead	-6	-105	12	-6	5	1	0	2	
Live	0	-1	0	0	0	0	0	0	
Seismic	34	325	176	38	25	13	2	8	
1	-9	-149	17	-9	7	1	0	3	1.4 D + 1.7 L
2	28	219	188	31	30	14	2	10	D + L + Es
3	28	219	-164	-44	-20	-12	-3	-6	D + L + E's
4	-40	-431	-164	-44	-20	-12	-3	-6	D + L - Es
5	-40	-431	188	31	30	14	2	10	D + L - E's
6	28	230	187	32	29	14	2	10	0.9 D + Es
7	28	230	-166	-44	-20	-12	-3	-7	0.9 D + E's
19(2)	77	227	186	36	-58	7	3	11	D + L + E's + αTo(W1)
37(2)	77	238	186	36	-58	7	3	11	0.9 D + E's + αTo(W2)

x-direction is horizontal; y-direction is vertical.

Element number:	11514
[Plate thickness required for load combinations excluding thermal:	*0.40 inches + 2%(1)]**
[Plate thickness required for load combinations including thermal:	*0.40 inches + 2%(1)]**
[Plate thickness provided:	*0.75 inches]**
[Shear reinforcement required for load combinations excluding thermal:	*0.07 in²/ft² + 2%(1)]**
[Shear reinforcement required for load combinations including thermal:	*0.08 in²/ft² + 2%(1)]**
Shear reinforcement provided:	See [*APP-GW-GLR-602, Section 4*]*

Notes:

1. [*The Tier 2* designation for "Plate thickness required" requires NRC approval if this value is exceeded as a result of design changes or detail design adjustments identified during preparation of fabrication or construction drawings or instructions.*]*
2. Load cases 19 and 37 are the two governing load combinations for element 11514 that include thermal and seismic loads combined numerically. W1 designates the winter conditions with the spent fuel pool at the normal operating temperature limit. W2 designates the winter conditions with the spent fuel pool and fuel transfer canal at the normal operating temperature limit. Es is SRSS (member forces are positive) of the SSE loads. E's is Es with all member forces except axial forces (TX, TY) reversed to negative.

Comment [rmk125]: 9
Comment [tlw126]: 37
Comment [h127]: 37
Comment [tlw128]: 37
Comment [h129]: 37
Comment [tlw130]: 37
Comment [tlw131]: 37
Comment [tlw132]: 9
Comment [tlw133]: 37
Comment [tlw134]: 9
Comment [h135]: 37

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-14 (Sheet 3 of 3)

DESIGN SUMMARY OF ENHANCED SHIELD BUILDING LOAD COMBINATIONS, AND COMPARISON TO ACCEPTANCE CRITERIA ELEVATION GRADE ON WEST SIDE

Load/Combination	TX kip/ft	TY kip/ft	TXY kip/ft	MX k-ft/ft	MY k-ft/ft	MXY k-ft/ft	NX kip/ft	NY kip/ft	Comments
Dead	2	-127	0	2	19	0	0	-2	
Live	0	1	0	0	0	0	0	0	
Seismic	58	477	231	2	16	17	4	7	
1	2	-176	-1	3	26	0	0	-3	1.4 D + 1.7 L
2	60	352	231	4	35	18	4	5	D + L + Es
3	60	352	-232	1	2	-17	-4	-9	D + L + E's
4	-57	-603	-232	1	2	-17	-4	-9	D + L - Es
5	-57	-603	231	4	35	18	4	5	D + L - E's
6	60	364	231	4	33	18	4	5	0.9 D + Es
7	60	364	-232	0	1	-17	-4	-9	0.9 D + E's
23(2)	182	364	-238	113	155	-17	-4	-31	D + L + E's + αTo(W1)
41(2)	182	380	-238	113	153	-17	-4	-31	0.9 D + E's + αTo(W2)

x-direction is horizontal; y-direction is vertical.

Element number:	23752
[Plate thickness required for load combinations excluding thermal:	*0.56 inches + 2%(1)]**
[Plate thickness required for load combinations including thermal:	*0.58 inches + 2%(1)]**
[Plate thickness provided:	*0.75 inches]**
[Shear reinforcement required for load combinations excluding thermal:	*0.06 in²/ft² + 2%(1)]**
[Shear reinforcement required for load combinations including thermal:	*0.21 in²/ft² + 2%(1)]**
Shear reinforcement provided:	See *[APP-GW-GLR-602, Section 4]**

Notes:

1. *[The Tier 2* designation for "Plate thickness required" requires NRC approval if this value is exceeded as a result of design changes or detail design adjustments identified during preparation of fabrication or construction drawings or instructions.]**
2. Load cases 23 and 41 are the two governing load combinations for element 23752 that include thermal and seismic loads combined numerically. W1 designates the winter conditions with the spent fuel pool at the normal operating temperature limit. W2 designates the winter conditions with the spent fuel pool and fuel transfer canal at the normal operating temperature limit. Es is SRSS (member forces are positive) of the SSE loads. E's is Es with all member forces except axial forces (TX, TY) reversed to negative.

Comment [rmk136]: 9
Comment [tlw137]: 37
Comment [h138]: 37
Comment [tlw139]: 37
Comment [h140]: 37
Comment [tlw141]: 37
Comment [tlw142]: 37
Comment [tlw143]: 9
Comment [tlw144]: 37
Comment [tlw145]: 9
Comment [h146]: 37

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 3H.5-15

Comment [tlw147]: 37

SHIELD BUILDING ROOF REINFORCEMENT RATIO OF CODE REQUIRED VERSUS PROVIDED

Critical Sections	**Stress Component**	**Required in^2/ft**	**Provided (Minimum) in^2/ft**	**Reinforcement Ratio**
*[Conical Roof Steel Beams]** (1)	Axial + Bending	-	*[Radial Beams W36 X 393]**	1.33
	Shear	-		8.33
*[Conical Roof Near Tension Ring]**	Radial	1.80	*[1.96]**	1.09
	Hoop	4.31	*[4.68]**	1.09
*[Knuckle Region]**	Vertical	1.37	*[1.72]**	1.25
	Radial	1.52	*[2.23]**	1.47
	Hoop	1.37	*[3.12]**	2.28
*[Compression Ring]**	Vertical	1.04	*[1.48]**	1.42
	Radial	3.09	*[4.42]**	1.43
	Hoop	2.14	*[3.12]**	1.45

Note:

1. Steel beams are not considered as reinforcement for the reinforced concrete roof. Ratio for conical roof steel beams is based on demand and allowable stresses in psi.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Comment [tlw148]: 37

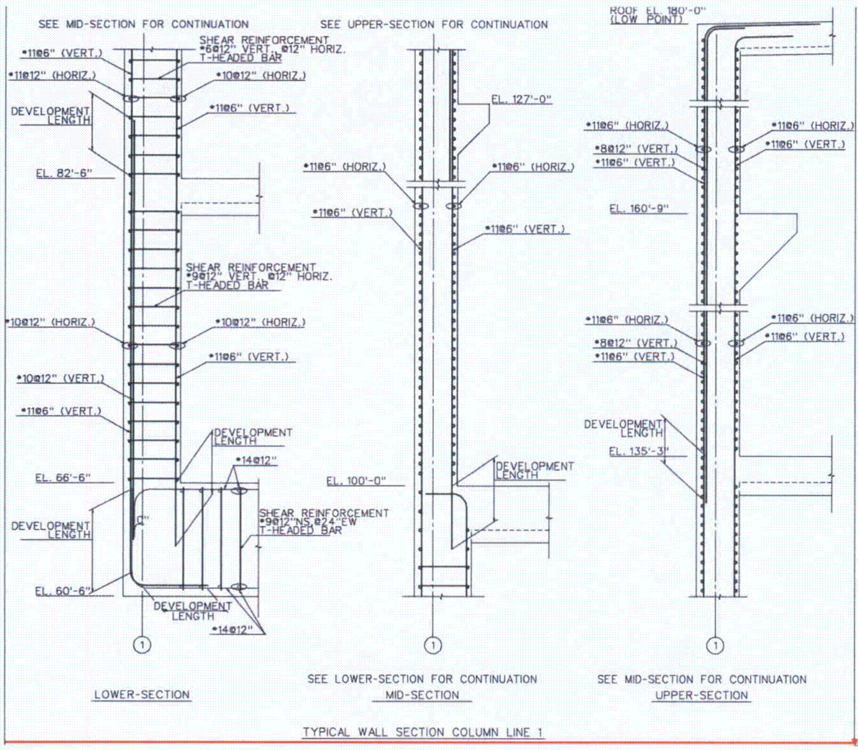

Figure 3H.5-3

*[Typical Reinforcement in Wall on Column Line 1]**

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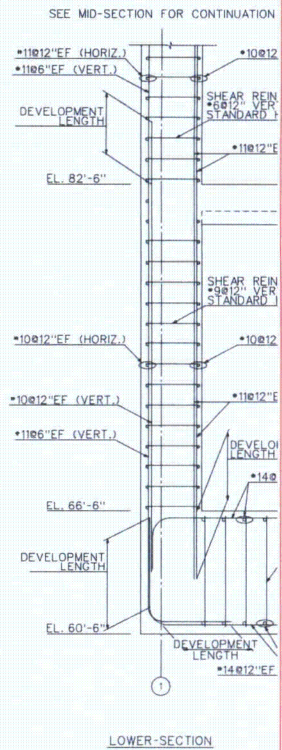


*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Comment [tlw160]: 37

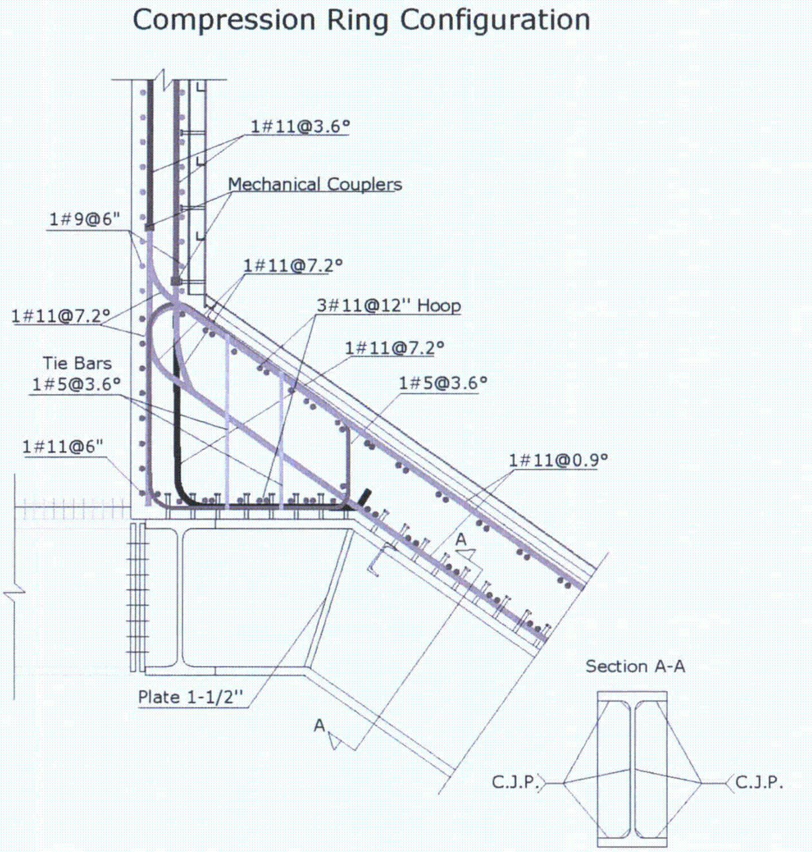
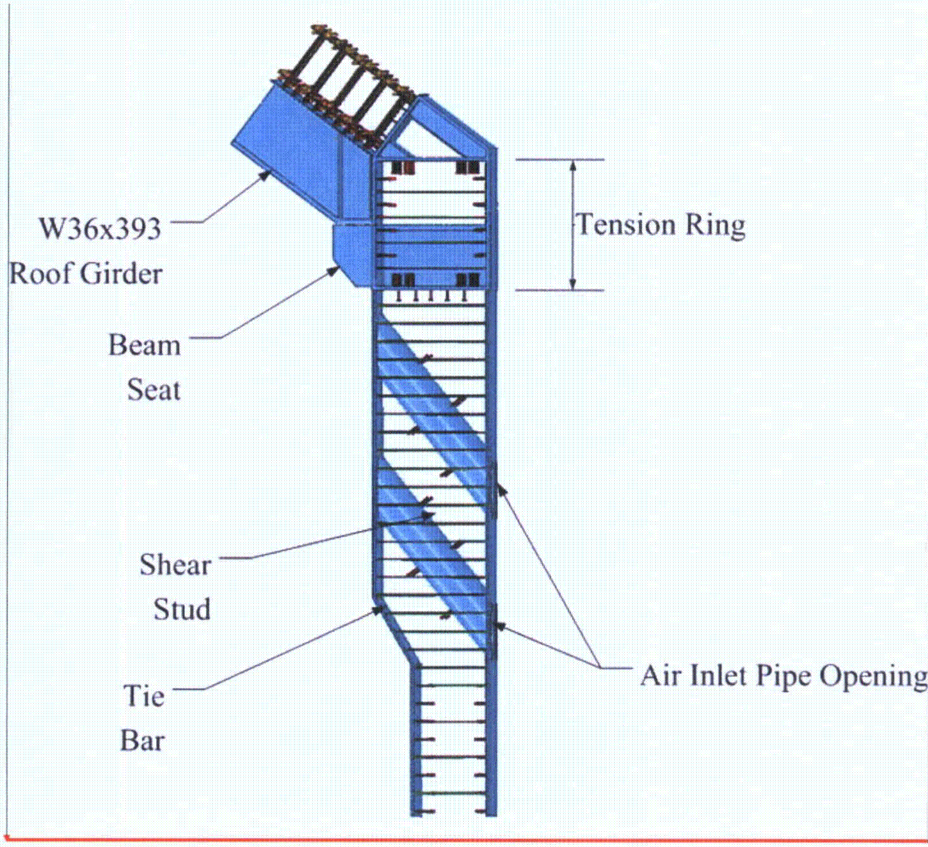


Figure 3H.5-11 (Sheet 6 of 6)

Design of Shield Building: Tank/Compression Ring Roof Interface Reinforcement

Comment [tlw161]: 9



Comment [tlw162]: 9

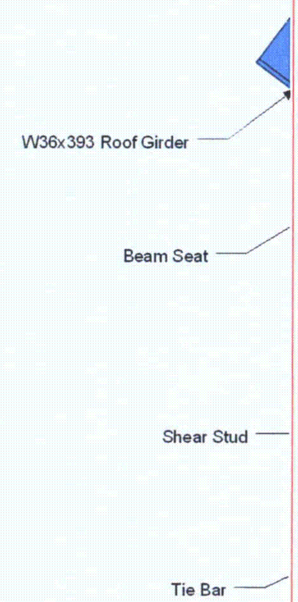


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Figure 3H.5-14

Elevation View of Tension Ring and Air Inlets

ENCLOSURE 5

Markup of DCD Revision 18, Section Appendix 3I

3I.3 NI Models Used To Develop High Frequency Response

The NI20 nuclear island model described in Appendix 3G is analyzed in ACS SASSI using the HRHF time histories applied at foundation level to obtain the motion at the base.

A modal analysis of the NI05 model for both the auxiliary and shield buildings and containment internal structure (CIS) has been performed for each of these regions. Specific areas within each wall or floor where out-of-plane modes, which may respond to either CSDRS or HRHF input (including structures with modes less than 33 Hz and between 33 Hz to 50 Hz), have been identified. The survey reveals that some regions, typically in the middle of a floor or wall, exhibit amplified behavior compared to the critical nodes at the corner and edge building locations. The amplified FRS for these regions is generated in addition to the typical set of critical nodes for building analysis by a single time history analysis of the NI05 building model subject to the HRHF time history input. Seismic response spectra for each of the "flexible" nodes are considered when selecting the pre-existing "group" spectra, which is the envelope of the entire floor in that area.

Evaluation of incoherent HRHF spectra has been performed. The CSDRS and HRHF seismic responses were compared with coherent and incoherent considerations at a number of locations in the nuclear island. There are some exceedances, mostly above the 15 hertz region, and these are typical of the plant comparative responses. The steel containment vessel (SCV) was excluded from the evaluation because the HRHF spectra at the base of the SCV are enveloped by the AP1000 CSDRS spectra at the base of the SCV.

Structures designed to the CSDRS input are adequately designed for the HRHF input because the HRHF coherent results are enveloped by the CSDRS results.

Comment [tlw1]: 12

Comment [tlw2]: 12

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Comment [tlw3]: 12

Comment [tlw4]: 12

Comment [rmk5]: 12

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3I.4 Evaluation Methodology

The demonstration that the AP1000 nuclear power plant is qualified for the high frequency seismic response does not require the analysis of the total plant. The evaluations made are of representative systems, structures, and components, selected by screening, as potentially sensitive to high frequency input in locations where there were exceedances in the high frequency region. Acceptability of this sample is considered sufficient to demonstrate that the AP1000 is qualified.

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

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

The evaluations performed assess the ability of the system, structure, or component to maintain its safety function.

ENCLOSURE 7

Markup of DCD Revision 18, Section 3.7 and Appendix 3H figures that include SUNSI -

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Figure 3.7.2-12 (Sheet 7 of 12)

*[Nuclear Island Key Structural Dimensions Plan at El. 160'-6", 180'-0", & 329'-0"]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Redacted Version, Withheld Under 10 CFR 2.390d

Figure 3H.5-11 (Sheet 1 of 6)

*[Design of Shield Building: Roof and Air Inlets]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

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Figure 3H.5-11 (Sheet 2 of 6)

[*Design of Shield Building: Concrete Detail at Tension Ring*]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Redacted Version, Withheld Under 10 CFR 2.390d

Figure 3H.5-11 (Sheet 3 of 6)

[*Design of Shield Building: Roof/Air Inlet Interface*]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

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Figure 3H.5-11 (Sheet 4 of 6)

*[Design of Shield Building at Air Inlets]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

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Figure 3H.5-11 (Sheet 5 of 6)

*[Design of Shield Building: Tank/Roof Interface Reinforcement]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Redacted Version, Withheld Under 10 CFR 2.390d

For additional information, see Figure 6 of APP-GW-GLR-602 (Reference 1).

Figure 3H.5-16 (Sheet 1 of 2)

*[Design of Shield Building: Surface Plates on Cylindrical Section – Developed View 90-270 Degrees]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Redacted Version, Withheld Under 10 CFR 2.390d

For additional information, see Figure 6 of APP-GW-GLR-602 (Reference 1).

Figure 3H.5-16 (Sheet 2 of 2)

[Design of Shield Building: Surface Plates on Cylindrical Section – Developed View 270-90 Degrees]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

DCP_NRC_003161
June 12, 2011

ENCLOSURE 8

Markup of DCD Revision 18, Tier 1

Table 3.3-1
Definition of Wall Thicknesses for Nuclear Island Buildings, Turbine Building, and Annex Building(1)

Wall or Section Description	Column Lines	Floor Elevation or Elevation Range	Concrete Thickness(2)(3)(4)(5)	Applicable Radiation Shielding Wall (Yes/No)
Containment Building Internal Structure				
Shield Wall between Reactor Vessel Cavity and RCDT Room	E-W wall parallel with column line 7	From 71'-6" to 83'-0"	3'-0"	Yes
West Reactor Vessel Cavity Wall	N-S wall parallel with column line N	From 83'-0" to 98'-0"	7'-6"	Yes
North Reactor Vessel Cavity Wall	E-W wall parallel with column line 7	From 83'-0" to 98'-0"	9'-0"	Yes
East Reactor Vessel Cavity Wall	N-S wall parallel with column line N	From 83'-0" to 98'-0"	7'-6"	Yes
West Refueling Cavity Wall	N-S wall parallel with column line N	From 98'-0" to 135'-3"	4'-0"	Yes
North Refueling Cavity Wall	E-W wall parallel with column line 7	From 98'-0" to 135'-3"	4'-0"	Yes
East Refueling Cavity Wall	N-S wall parallel with column line N	From 98'-0" to 135'-3"	4'-0"	Yes
South Refueling Cavity Wall	E-W wall parallel with column line 7	From 98'-0" to 135'-3"	4'-0"	Yes
South wall of west steam generator compartment	Not Applicable	From 103'-0" to 153'-0"	2'-6"	Yes
West wall of west steam generator compartment	Not Applicable	From 103'-0" to 153'-0"	2'-6"	Yes
North wall of west steam generator compartment	Not Applicable	From 103'-0" to 153'-0"	2'-6"	Yes
South wall of pressurizer compartment	Not Applicable	From 103'-0" to 153'-6"	2'-6"	Yes
West wall of pressurizer compartment	Not Applicable	From 107'-2" to 160'-0"	2'-6"	Yes
North wall of pressurizer compartment	Not Applicable	From 107'-2" to 160'-0"	2'-6"	Yes
East wall of pressurizer compartment	Not Applicable	From 118'-6" to 160'-0"	2'-6"	Yes
North-east wall of in-containment refueling water storage tank	Parallel to column line N	From 103'-0" to 135'-3"	2'-6"	No
West wall of in-containment refueling water storage tank	Not applicable	From 103'-0" to 135'-3"	5/8" steel plate with stiffeners	No
South wall of east steam generator compartment	Not Applicable	From 87'-6" to 153'-0"	2'-6"	Yes

1. The column lines and floor elevations are identified and included on Figures 3.3-1 through 3.3-13.
2. These wall (and floor) thicknesses have a construction tolerance of ± 1 inch, except for exterior walls below grade where the tolerance is +12 inches, - 1 inch.
3. For walls that are part of structural modules, the concrete thickness also includes the steel face plates.
4. For floors with steel surface plates, the concrete thickness also includes the plate thickness.
5. Where a wall (or a floor) has openings, the concrete thickness does not apply at the opening.
6. The elevation ranges for the shield building items are rounded to the nearest inch.

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Table 3.3-1 (cont.)
Definition of Wall Thicknesses for Nuclear Island Buildings, Turbine Building, and Annex Building(1)

Wall or Section Description	Column Lines	Floor Elevation or Elevation Range	Concrete Thickness(2)(3)	Applicable Radiation Shielding Wall (Yes/No)
East wall of east steam generator compartment	Not Applicable	From 94'-0" to 153'-0"	2'-6"	Yes
North wall of east steam generator compartment	Not Applicable	From 87'-6" to 153'-0"	2'-6"	Yes
Shield Building(9)				
Shield Building Cylinder	Not Applicable	From 100'-0" to 248'-6"	3'-0" (including 3/4 inch thick min. steel plate liner on each face on portion not protected by auxiliary building)	Yes
Air Inlet	Not Applicable	From 248'-6" to 251'-6"	3'-0" (including 3/4 inch thick min. steel plate liner on each face)	Yes
		From 251'-6" to 254'-6"	3'-0" to 4'-6" (including 1 inch thick steel plate liner on each face)	Yes
		From 254'-6" to 266'-4"	4'-6" (including 1 inch thick min. steel plate liner on each face)	Yes
Tension Ring	Not Applicable	From 266'-4" to 271-6" (at top of plate)	4'-6" (including 1-1/2 inch thick steel plate liner on each face)	Yes
Conical Roof	Not Applicable	From 271'-6" to 293'-9"	3'-0" (including 1/2 inch thick min. steel plate liner on bottom face, outside of PCS tank exterior wall)	Yes
PCS Tank External Cylindrical Wall	Not Applicable	From 293'-9" to 328'-9"	2'-0"	Yes

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Table 3.3-6 (cont.)
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
13. Separation is provided between the structural elements of the turbine, annex and radwaste buildings and the nuclear island structure. This separation permits horizontal motion of the buildings in the safe shutdown earthquake without impact between structural elements of the buildings.	An inspection of the separation of the nuclear island from the annex, radwaste and turbine building structures will be performed. The inspection will verify the specified horizontal clearance between structural elements of the adjacent buildings, consisting of the reinforced concrete walls and slabs, structural steel columns and floor beams.	The minimum horizontal clearance above floor elevation 100′-0″ between the structural elements of the annex and radwaste buildings and the nuclear island is 4 inches. The minimum horizontal clearance above floor elevation 100′-0″ between the structural elements of the turbine building and the nuclear island is 4 inches.
14. The external walls, doors, ceiling, and floors in the main control room, the central alarm station, and the secondary alarm station are bullet-resistant to at least Underwriters Laboratory Ballistic Standard 752, level 4.	Type test, analysis, or a combination of type test and analysis will be performed for the external walls, doors, ceilings, and floors in the main control room, the central alarm station, and the secondary alarm station.	A report exists and concludes that the external walls, doors, ceilings, and floors in the main control room, the central alarm station, and the secondary alarm station are bullet-resistant to at least Underwriters Laboratory Ballistic Standard 752, level 4.
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16. Secondary security power supply system for alarm annunciator equipment and non-portable communications equipment is located within a vital area.	An inspection will be performed to ensure that the location of the secondary security power supply equipment for alarm annunciator equipment and non-portable communications equipment is within a vital area.	Secondary security power supply equipment for alarm annunciator equipment and non-portable communication equipment is located within a vital area.
17. Vital areas are locked and alarmed with active intrusion detection systems that annunciate in the central and secondary alarm stations upon intrusion into a vital area.	An inspection of the as-built vital areas, and central and secondary alarm stations are performed.	Vital areas are locked and alarmed with active intrusion detection systems and intrusion is detected and annunciated in both the central and secondary alarm stations.
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Table 3.3-7 Nuclear Island Critical Structural Sections
Containment Internal Structures
South west wall of the refueling cavity
South wall of the west steam generator cavity
North east wall of the in-containment refueling water storage tank
In-containment refueling water storage tank steel wall
Column supporting the operating floor
Auxiliary and Shield Building
South wall of auxiliary building (column line 1), elevation 66'-6" to elevation 180'-0"
Interior wall of auxiliary building (column line 7.3), elevation 66'-6" to elevation 160'-6"
West wall of main control room in auxiliary building (column line L), elevation 117'-6" to elevation 153'-0"
North wall of MSIV east compartment (column line 11 between lines L and M), elevation 117'-6" to elevation 153'-0"
Roof slab at elevation 180'-0" adjacent to shield building cylinder
Floor slab on metal decking at elevation 135'-3"
2'-0" slab in auxiliary building (tagging room ceiling) at elevation 135'-3"
Finned floor in the main control room at elevation 135'-3"
Shield building roof, exterior wall of the PCS water storage tank
Shield building roof, interior wall of the PCS water storage tank
Shield building roof, tension ring and air inlets
Divider wall between the spent fuel pool and the fuel transfer canal
Shield building SC cylinder
Shield building SC to RC connection
Nuclear Island Basemat Below Auxiliary Building
Bay between reference column lines 9.1 and 11, and K and L
Bay between reference column lines 1 and 2 and K-2 and N

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RC/SC Shield Building Connections
Shield Building Air Inlet And Tension Ring

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ENCLOSURE 9

Markup of DCD Revision 18, Tier 2, Table 1.6-1

Table 1.6-1 (Sheet 4 of 21)

MATERIAL REFERENCED

DCD Section Number	Westinghouse Topical Report Number	Title
3.8	WCAP-13891 (P) WCAP-14095	AP600 Automatic Depressurization System Phase A Test Data Report, May 1994
	WCAP-14324 (P) WCAP-14325	Final Data Report for ADS Phase B1 Tests, April 1995
	WCAP-15613 (P) WCAP-15706	AP1000 PIRT and Scaling Assessment, March 2001
	[*APP-GW-GLR-602*	*AP1000 Shield Building Design Details for Select Wall and RC/SC Connections, Revision 1, Westinghouse Electric Company LLC*]*
3.9	WCAP-7765-AR	Westinghouse PWR Internals Vibrations Summary Three-Loop Internals Assurance, November 1973
	WCAP-8766 (P) WCAP-8780	Verification of Neutron Pad and 17x17 Guide Tube Designs by Preoperational Tests on the Trojan 1 Power Plant, May 1976
	WCAP-8516-P (P) WCAP-8517	UHI Plant Internals Vibrations Measurement Program and Pre- and Post-Hot Functional Examinations, March 1975
	WCAP-10846 (P)	Doel 4 Reactor Internals Flow-Induced Vibration Measurement Program, March 1985
	WCAP-10865 (P) WCAP-10866	South Texas Plant (TGX) Reactor Internals Flow-Induced Vibration Assessment, February 1985
	WCAP-8708-P-A (P) Volumes 1 and 2 WCAP-8709-A Volumes 1 and 2	MULTIFLEX A FORTRAN-IV Computer Program for Analyzing Thermal-Hydraulic-Structure System Dynamics, February 1976
	WCAP-8446 (P) WCAP-8449	17x17 Drive Line Components Tests – Phase 1B 11, 111 D-Loop Drop and Deflection, December 1974
	WCAP-9693 (P)	Investigation of Feedwater Line Cracking in Pressurized Water Reactor Plants, June 1980
	WCAP-15949-P (P) WCAP-15949-NP	AP1000 Reactor Internals Flow-Induced Vibration Assessment Program, Revision 1, July 2003
	WCAP-16687-P (P)	AP1000 Reactor Internals Expected and Acceptable Responses During Preoperational Vibration Measurement Program, March 2007

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(P) Denotes Document is Proprietary
*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Table 1.6-1 (Sheet 5 of 21)

MATERIAL REFERENCED

DCD Section Number	Westinghouse Topical Report Number	Title
3H	[*APP-GW-GLR-602*	*AP1000 Shield Building Design Details for Select Wall and RC/SC Connections, Revision 1, Westinghouse Electric Company LLC*]*
4.1	WCAP-10444-P-A (P) WCAP-10445-NP-A	Reference Core Report VANTAGE 5 Fuel Assembly, September 1985, and VANTAGE 5H Fuel Assembly, Addendum 2A, February 1989
	WCAP-12610-P-A (P) WCAP-14342-A	VANTAGE+ Fuel Assembly Reference Core Report, April 1995
	[*WCAP-12488-A (P)* [*WCAP-14204-A*]*	*Fuel Criteria Evaluation Process, October 1994*]*
4.2	[*WCAP-12488-A (P)* [*WCAP-14204-A*]*	*Fuel Criteria Evaluation Process, October 1994*]*
	WCAP-10125-P-A (P) WCAP-10126-NP-A	Extended Burnup Evaluation of Westinghouse Fuel, December 1985
	WCAP-8183	Operational Experience with Westinghouse Cores (Revised Annually)
	WCAP-9179 (P) WCAP-9224	Properties of Fuel and Core Component Materials, July 1978
	WCAP-12610-P-A (P) WCAP-14342-A	VANTAGE+ Fuel Assembly Reference Core Report, June 1990/April 1995
	WCAP-8218-P-A (P) WCAP-8219-A	Fuel Densification Experimental Results and Model for Reactor Application, March 1975
	WCAP-10851-P-A (P) WCAP-11873-A	Improved Fuel Performance Models for Westinghouse Fuel Rod Design and Safety Evaluations, August 1988
	WCAP-13589-A (P) WCAP-14297-A	Assessment of Clad Flattening and Densification Power Spike Factor Elimination in Westinghouse Nuclear Fuel, March 1995
	WCAP-8963-P-A (P) WCAP-8964-A	Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, August 1977
	WCAP-10021-P-A (P) WCAP-10377-NP-A	Westinghouse Wet Annular Burnable Absorber Evaluation Report, Revision 1, October 1983
	WCAP-10444-P-A (P) WCAP-10445-NP-A	Reference Core Report VANTAGE 5 Fuel Assembly, September 1985

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