RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification
Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD
Docket No. 52-046

RAI No.:	**248-8295**
SRP Section:	**03.08.05 - Foundations**
Application Section:	**3.8.5**
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Question No. 03.08.05-1

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section I, “Areas of Review,” in item 1, “Description of the Containment,” states that “The reviewer examines the arrangement of the containment and the relationship and interaction of the shell with its surrounding structures and with its interior compartment walls and floors to determine the effect of these structures on the design boundary conditions and expected structural behavior of the containment when subjected to design loads.” SRP 3.8.3, Section I, “Areas of Review,” in item 1, “Description of the Internal Structures,” sub-item A.v., “Other Interior Structures,” states that “The review also evaluates other major interior structures of PWR dry containments in a similar manner, including the concrete refueling pool walls, refueling water storage tank (if applicable), the operating floor, other intermediate floors and platforms, and the polar crane supporting elements.” SRP 3.8.4, Appendix C to SRP Section 3.8.4, “Design Report,” in item I., “Objective,” states that “The primary objective of the design report provided by the applicant is to supply the reviewer with design and construction information more specific than that contained in the SARs. This information can assist the reviewer in planning and conducting a structural audit. For this review, the information must be in quantitative form representing the scope of the actual design computations and the final design results. The design report should also provide criteria for reconciliation between design and as-built conditions.” SRP Item II.2, “Key Structural Elements and Description,” states that the design report should provide descriptions of the key (critical) structural elements.

APR1400 DCD Tier 2, Section 3.8A.1.4.1.3.5, “Design Sections,” identifies the portion of the containment structure considered to be critical design sections. The applicant identified the base of the containment wall, the mid-height of the containment wall, the polar crane bracket level and springline, and the thickened sections around large penetrations, such as the equipment hatch and the personnel airlock. The staff reviewed the list of critical sections and noted that the critical sections for the dome, steel plate liner to the containment, and mainsteam and feedwater penetrations appears to be missing. Therefore, per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.1 and 3.8.5, the applicant is requested to address the following:

a. Whether any other critical sections such as the dome; steel plate liner to the containment; floor slab between the SSW and the containment, and a steel beam and/or column; and mainsteam and feedwater penetrations are identified as critical sections. If so, the applicable portion of the DCD should be updated accordingly.

b. In Section 3.8A.2.4, “Analysis and Design for Critical Sections”, the applicant stated, “The locations of critical sections are shown in Figures 3.8A-25 through 3.8A-28 and the location of the concrete frame is shown in Figure 3.8A-53.” The staff noticed that figure does not show a concrete frame for the AB, but instead shows several walls of the EDG building. The applicant is requested to provide the appropriate figure.

c. In the case of some structures, the required strength or steel reinforcement and the provided values, along with the margins of safety, for the critical sections, are presented (e.g., Table 3.8A-27 for the AB basemat). However, for other structures this information is not provided. Therefore, for all critical sections for all structures, where this information is lacking, the applicant is requested to include this data in the appropriate tables. Note in the case of the containment basemat this information was provided for the steel reinforcement but not for the concrete stress.

Response

a. The critical design sections are the portions of safety related, seismic category I structures, which are credited in prevention or mitigation of consequences of postulated design basis accidents, expected to experience the largest structural demands during design basis conditions, or needed for safety evaluation of an essentially complete design.

To determine the critical design sections, structural types and materials such as concrete or steel, structural configurations representing locations and discontinuities are basically considered. Some selected critical sections may be typical of other portions of the structure, where the portions are not identified as critical sections due to their similarities with the selected design critical sections. In this case, the critical design sections are representative of an essentially complete structural design, and their design adequacy provides reasonable assurance of overall plant structural design.

Although certain portions are not subject to limiting structural demands, or can be considered less critical, they are necessarily selected as critical sections due to their specific aspects, such as design code and criteria. This may be a significant consideration because the structural demand based critical sections represent only those portions of a structure that experience high loads or stress and may not identify intervening structural elements that are not subject to high stress or loading, but are needed for evaluating structural integrity.

In addition to structural features, safety related functional role is also considered in selecting critical design sections. Some of the APR1400 structures are required to achieve major performance; failure could degrade systems or equipment or pose a safety hazard to plant personnel or to the general public.

The above criteria may be applied not only as one criterion, but also as mixed criteria, based on engineering judgment and consistency. The specific contents for the critical design structures are presented in Section 3.8A.1 through 3.8A.3 of the DCD, and more detailed features in each structure can be further broken into portions, as described in each subsection of the DCD.

Practically, there is no concrete or steel column in the reactor containment building, and steel beams are out of scope for the APR1400 standard design. In the list of critical design sections in DCD Tier 2, Section 3.8A.1.4.1.3.5, containment dome and liner plate are missing. For the containment liner plate, the design procedure and criteria are described in Section 3.8.1.4.10, and the design results, including the margin of safety, are presented in Table 3.8-12 in the DCD.

Accordingly, Sections 3.8A.1.4.1.3.4 through 3.8A.1.4.1.3.7, and Tables 3.8A-2 and 3.8A-3 will be modified, and Figure 3.8A-57 will be added for the missing items, as shown in Attachment 1 to this response.

b. This is an editorial error since the concrete frame has not been designed for critical sections, as described in Section 3.8A.2.4. Therefore, the associated description in the DCD will be deleted, as shown in Attachment 2 to this response.

c. In DCD Tier 2, between Table 3.8A-23 and Table 3.8A-24, the information of margin of safety for IRWST structure is missing. Accordingly, Section 3.8A.1.4.3.2.3 will be modified, and Table 3.8A-40 will be added for the missing information, as shown in Attachment 3.

In addition, the information of concrete stress for all the RCB structures including the containment basemat will be added by revising the Tables 3.8A-4, -10, -22, -25, and -40, as shown in Attachment 3 to this response.

Impact on DCD

DCD Tier 2, Subsections 3.8A.1.4.1.3.4 through 3.8A.1.4.1.3.7 for Question “a”, Subsection 3.8A.2.4 for Question “b”, and Subsections 3.8A.1.4.2.3.1, 3.8A.1.4.3.1.3, 3.8A.1.4.3.2.3, 3.8A.1.4.3.3.3 for Question “c” will be revised, as described in the attachments associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Seismic Load

Structural analysis for the seismic load is based on the response spectrum analysis method, which computes the maximum response of a structure from the results of a modal analysis and their combinations. For the containment wall and dome, the in-structure response spectrum at El. 78 ft 0 in is used as a base excitation input. Figure 3.8A-5(b) shows the in-structure response spectrum of the safe shutdown earthquake (SSE) level at El. 78 ft 0 in with 5 percent damping.

3.8A.1.4.1.3.4 Analysis Results

The section forces and moments for each element are calculated from the integration of stress resultants, which are obtained from various FE analysis results. The maximum section forces and moments for the principal design sections of the containment wall are summarized in Table 3.8A-2.

and dome

3.8A.1.4.1.3.5 Design Sections

Critical sections are those portions of the containment wall and dome that (1) perform a safety-critical function, (2) are subjected to the largest stress demands, (3) are considered to be representative of the structural design, and (4) provide reasonable assurance that the structural design is being performed in a manner consistent with the guidance in the SRP, Regulatory Guides, and other regulatory requirements.

The sections at geometric discontinuities and the expected maximum stress location are considered as critical design sections. The major design sections for the containment wall are as follows:

and dome structures including liner plate

Specific aspects of structures such as design code and criteria are also taken into account.

a. Base of containment wall (wall-basemat junction)

b. Mid-height of wall

c. Polar crane bracket level and springline

d. Thickened sections around large penetrations

1) Equipment hatch

2) Personnel airlock

e. Containment dome

f. Comtainment liner plate

3.8A.1.4.1.3.6 Rebar Arrangement

Continuous vertical and horizontal reinforcements are placed at the inside and outside faces of the containment wall. The vertical reinforcements of the containment wall are extended and anchored to the basemat. Additional reinforcing bars are provided around the large penetrations in the cylindrical wall as required. Shear ties are also provided where shear reinforcing is required.

, and 3.8A-57

and dome

s

Table 3.8A-3 summarizes the reinforcing details for the major design sections of the containment wall. Figures 3.8A-6 through 3.8A-10 show the rebar arrangement for the major design sections of the containment wall. Figure 3.8A-16 and 3.8A-17 show the connection detail between the containment wall and basemat.

and dome

The containment dome is also reinforced by two-way orthogonal sets of vertical reinforcing steel and hoop reinforcing steel. The orthogonal reinforcing is the continuation of the vertical reinforcing in the containment wall. Hoop reinforcing is also provided up to 45 degrees above the springline. Radial reinforcements are provided over the entire dome to resist radial tension forces resulting from curved tendons.

3.8A.1.4.1.3.7 Design Results

The design sections of the containment wall and dome are analyzed by the computer program DARTEM to check the stresses of concrete and reinforcing steel in the concrete section. The input of DARTEM consists of section geometry, material properties, section forces and moments, and loading combinations. Table 3.8A-4 presents the rebar stresses and margins of safety for the major design sections of the containment. The margin of safety is the ratio of allowable stress and actual stress of ~~reinforcement~~ in the containment.

and concrete

rebar and concrete

The design procedure and criteria for the containment liner plate are described in Subsection 3.8.1.4.10, and the design results, including the margin of safety, are presented in Table 3.8-12.

and Dome

Table 3.8A-2 (1 of 2)

Section Forces of Containment Wall Design Sections

Wall-Basemat Junction Area

N_{Φ} (kip/ft)	M_{Φ} (kip-ft/ft)	$Q_{R\Phi}$ (kip/ft)	N_{θ} (kip/ft)	M_{θ} (kip-ft/ft)	$Q_{R\theta}$ (kip/ft)	Remark
376.56	-422.17	110.59	268.29	-78.46	8.05	Meridional Inside
363.30	253.54	38.88	333.86	54.11	5.66	Meridional Outside
331.52	52.21	6.19	373.59	-7.74	0.38	Hoop Inside
328.69	222.00	5.12	368.07	80.67	3.52	Hoop Outside

Mid-Height Level of Wall

N_{Φ} (kip/ft)	M_{Φ} (kip-ft/ft)	$Q_{R\Phi}$ (kip/ft)	N_{θ} (kip/ft)	M_{θ} (kip-ft/ft)	$Q_{R\theta}$ (kip/ft)	Remark
198.93	-271.97	27.44	241.72	29.67	11.22	Meridional Inside
233.67	124.91	11.05	288.59	152.77	4.50	Meridional Outside
-116.11	-53.26	3.34	373.32	-192.54	-38.69	Hoop Inside
-65.44	55.70	0.04	334.88	179.59	-1.67	Hoop Outside

Polar Crane Bracket Level and Springline

N_{Φ} (kip/ft)	M_{Φ} (kip-ft/ft)	$Q_{R\Phi}$ (kip/ft)	N_{θ} (kip/ft)	M_{θ} (kip-ft/ft)	$Q_{R\theta}$ (kip/ft)	Remark
41.49	-236.69	-4.45	152.44	-112.27	26.10	Meridional Inside
76.39	85.49	12.72	170.73	6.75	25.74	Meridional Outside
-8.07	-100.63	-2.30	389.97	-286.61	11.49	Hoop Inside
10.98	-78.75	-7.73	393.01	-274.63	-8.64	Hoop Outside

Table 3.8A-2 (2 of 2)

Equipment Hatch

N_{Φ} (kip/ft)	M_{Φ} (kip-ft/ft)	$Q_{R\Phi}$ (kip/ft)	N_{θ} (kip/ft)	M_{θ} (kip-ft/ft)	$Q_{R\theta}$ (kip/ft)	Remark
633.51	-900.58	59.89	443.77	-582.97	107.87	Meridional Inside
633.51	1,391.59	59.89	443.77	1,347.08	107.87	Meridional Outside
327.89	-375.99	-62.95	984.87	-1,121.67	-39.04	Hoop Inside
400.38	1,127.27	-14.59	682.06	1,119.63	-10.57	Hoop Outside

Personnel Airlock

N_{Φ} (kip/ft)	M_{Φ} (kip-ft/ft)	$Q_{R\Phi}$ (kip/ft)	N_{θ} (kip/ft)	M_{θ} (kip-ft/ft)	$Q_{R\theta}$ (kip/ft)	Remark
742.23	-641.62	47.73	821.82	-538.01	17.70	Meridional Inside
596.38	1,586.38	66.48	830.83	687.51	38.89	Meridional Outside
595.99	-678.43	58.22	855.75	-615.76	-6.09	Hoop Inside
595.99	1,558.64	58.22	855.75	621.13	-6.09	Hoop Outside

N_{Φ} = Meridional Force

M_{Φ} = Meridional Moment

$Q_{R\Phi}$ = Meridional Radial Shear Force

N_{θ} = Hoop Force

M_{θ} = Hoop Moment

$Q_{R\theta}$ = Hoop Radial Shear Force

Table added

Dome

N_{Φ} (kip/ft)	M_{Φ} (kip/ft)	$Q_{R\Phi}$ (kip/ft)	N_{Θ} (kip/ft)	M_{Θ} (kip/ft)	$Q_{R\Theta}$ (kip/ft)	Remark
84.76	67.80	-3.09	244.55	73.63	-0.37	Meridional Inside
84.76	67.80	-3.09	244.55	73.63	-0.37	Meridional Outside
84.76	67.80	-3.09	244.55	73.63	-0.37	Hoop Inside
84.76	67.80	-3.09	244.55	73.63	-0.37	Hoop Outside

Move

and Dome

Table 3.8A-3 (1 of 2)

Reinforcing Details of Containment Wall Design Sections

Wall-Basemat Junction Area

Direction		Rebar Arrangement
Meridional	Inside	Layer 1: #18+#14 @ 0.85° Layer 2: #18 @ 0.85°
	Outside	Layer 1: #18+#18 @ 0.85°
Hoop	Inside	Layer 1: #18 @ 12 in. Layer 2: #11 @ 12 in.
	Outside	Layer 1: #18 @ 12 in. Layer 2: #14 @ 12 in.

Mid-Height Level of Wall

Direction		Rebar Arrangement
Meridional	Inside	Layer 1: #18 @ 0.85°
	Outside	Layer 1: #18+#14 @ 0. 85°
Hoop	Inside	Layer 1: #18+#11 @ 12 in.
	Outside	Layer 1: #18 @ 12 in. Layer 2: #18 @ 12 in.

Polar Crane Bracket Level and Springline

Direction		Rebar Arrangement
Meridional	Inside	Layer 1: #14 @ 0.85° Layer 2: #14 @ 0.85°
	Outside	Layer 1: #18 @ 0.85°
Hoop	Inside	Layer 1: #18 + #14 @ 12 in.
	Outside	Layer 1: #18 @ 12 in. Layer 2: #18 @ 12 in.

Table 3.8A-3 (2 of 2)

Equipment Hatch

Direction		Rebar Arrangement
Meridional	Inside	Layer 1: #18+#14 @ 0.85° Layer 2: #18 @ 0.85°
	Outside	Layer 1: #18+#18 @ 0.85° Layer 2: #18+#18 @ 0.85° Layer 3: #18+#18 @ 0.85°
Hoop	Inside	Layer 1: #18 @ 6 in. Layer 2: #18 @ 6 in.
	Outside	Layer 1: #18 @ 6 in. Layer 2: #18 @ 12 in. Layer 3: #18 @ 12 in. Layer 4: #18 @ 12 in.

Personnel Airlock

Direction		Rebar Arrangement
Meridional	Inside	Layer 1: #18+#14 @ 0.85° Layer 2: #18 @ 0.85° Layer 3: #18 @ 0.85°
	Outside	Layer 1: #18+#18 @ 0.8° Layer 2: #18+#18 @ 0.8° Layer 3: #18+#18 @ 0.85°
Hoop	Inside	Layer 1: #18 @ 12 in. Layer 2: #11 @ 12 in.
	Outside	Layer 1: #18 @ 6 in. Layer 2: #18 @ 12 in. Layer 3: #18 @ 12 in. Layer 4: #14 @ 12 in.

Table added

Dome

Direction		Rebar Arrangement
Meridional	Inside	Layer 1: #14 @ 0.85°
	Outside	Layer 1: #18 @ 0.85°
Hoop	Inside	Layer 1: #18 @ 0.75°
	Outside	Layer 1: #18+#11 @ 0.75°

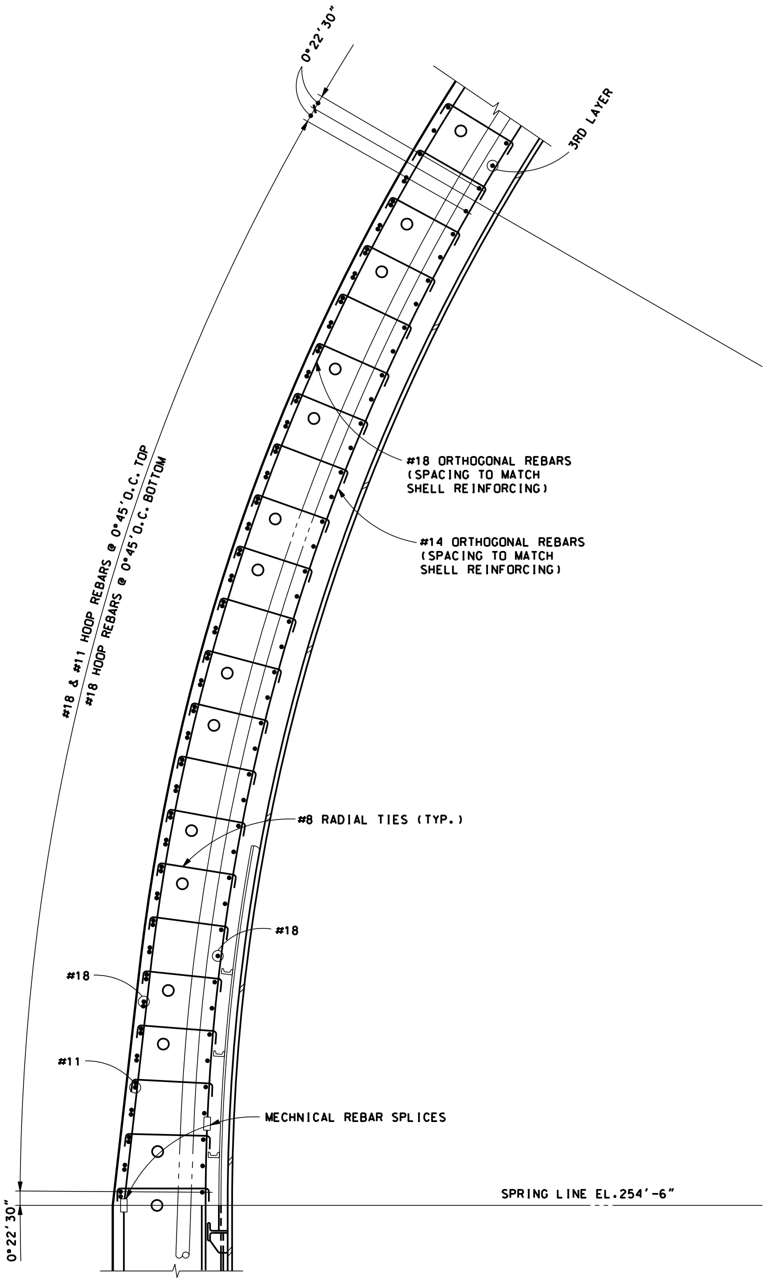

Figure 3.8-57 Rebar Arrangement of Containment Dome

Figure added

sections are shown in Figures 3.8A-25 through 3.8A-28 ~~and the location of the concrete frame is shown in Figure 3.8A-53~~.

a. Basemat

1) AB area of the nuclear island (NI) common basemat

b. Shear walls

1) North wall of the north main steam isolation valve (MSIV) house

2) North wall of the north auxiliary feedwater storage tank (AFWST)

3) West wall of the MCR

4) West wall of the spent fuel pool (SFP)

5) East wall of the fuel handling area (FHA)

c. Slabs

1) Floor slab of the EDG Room at El. 100 ft 0 inch

2) Pool bottom slab of the SFP at El. 113 ft 0 inch

3) Floor slab below the main steam enclosure at El. 137 ft 6 inch

3.8A.2.4.1 Basemat

Description

The AB shares a common foundation basemat with the RCB. The foundation of the RCB and AB is a reinforced concrete mat structure with the maximum dimensions of 106.0 m × 107.6 m (348 ft × 353 ft). The thickness of the basemat is 3.05 m (10 ft) in the AB area. The bottom of the basemat is located at El. 40 ft 0 in and 45 ft 0 in, below the finished grade elevation. The AB basemat is reinforced at the top and bottom with layers of reinforcing steel bars. The reinforcing bars are arranged in the orthogonal directions for top and bottom layers.

maximum water level used for the buoyancy loads calculation is El. 100 ft 0 in (ground level) for added conservatism. For SSE loads, the enveloped seismic loading from 10 analysis cases is conservatively used in each superstructure. The reactions from these analysis results are applied as nodal force to the basemat structure using the 100-40-40 effect of the three directions of seismic motion in which one component is taken at 100 percent of its maximum value and the others are taken at 40 percent of their maximum values.

The analysis results are expressed as the normal stresses and the shear stresses of solid elements. The stresses of solid elements are filed with respect to the rectangular and cylindrical coordinate systems to fit with the arrangements of reinforcement.

To envelop the flexural and shear reinforcement for the 36 load combinations, the RCB basemat is divided into eight design sections as represented in Table 3.8A-5. Figure 3.8A-15 shows design sections for the containment basemat.

Tables 3.8A-6 through 3.8A-9 show the calculated section forces and moments for the design. The calculated design forces and moments are used as input in the concrete section design program DARTEM for the design of flexural reinforcement and shear reinforcement. The design of the concrete sections is based on the ASME Section III, Division 2.

3.8A.1.4.2.3.1 Design Summary

The results on the design of the flexural and shear reinforcement are summarized in Tables 3.8A-10 through 3.8A-13. For the flexural reinforcement, it is confirmed that the maximum stresses of the provided reinforcement do not exceed the allowable stresses for both the service and factored load conditions. For the shear reinforcement, it is confirmed that the amounts of provided reinforcement are sufficient to meet the demands of the required reinforcement for each design section. The margins of safety of the flexural and shear reinforcement and concrete stresses are shown in Table 3.8A-10 and 3.8A-11~~, respectively~~. The design envelops the given parameters so that the design is adequate for any specific site conditions within those parameters. Figures 3.8A-16 and 3.8A-17 show the rebar arrangement for the basemat of the RCB.

c. SG compartment – SG blowdown nozzle

d. PZR compartment – PZR spray nozzle

e. PZR compartment – POSRV nozzle

f. PZR spray valve room – PZR spray line

Branch line pipe break (BLPB) loads are dynamic reactions caused by the combined effects of branch line nozzle reactions or thrust due to pipe break, jet impingement on RCS equipment, or subcompartment pressure effects on RCS equipment. The RCS support reactions due to BLPB are applied as nodal forces at the support locations.

The hydrodynamic pressure load, which is generated by the expulsion of air in the pilot-operated safety relief valve (POSRV) discharge, is applied to the wall and bottom slab of the IRWST through the two spargers. For the hydrodynamic pressure load, by multiplying the dynamic impact factor (DIF), the maximum pressure is conservatively considered as the static load in the analysis. In addition, the normalized factor is considered for the spatial distribution due to the location of spargers.

The seismic analysis for structures is performed using response spectrum analysis. A 7 percent damping ratio for reinforced concrete structures (SSE) and 3 percent damping ratio for the RCS model are used. In addition, the damping ratio for water in the IRWST or refueling pool is the same as that for reinforced concrete structures: the seismic response of water is only considered as impulsive (rigid) mode for structural analysis. Figure 3.8A-5 (a) and (c) show the in-structure response spectrum (ISRS) of the SSE level at El. 78 ft 0 in with 3 percent and 7 percent damping.

Three sections are selected in the PSW as critical sections. Each section is thinnest in the directions of north, south, and east. The design forces and moments for PSW critical sections are presented in the Table 3.8A-18. Table 3.8A-22 presents the margins of safety of rebar ~~stress~~ in the primary shield wall. The margin of safety is the ratio of allowable stress and actual stress.

and concrete stresses

3.8A.1.4.3.2.2 Load Combinations Considered

The following loading combinations are critical for the analysis and design of the IRWST wall:

a. Normal: $1.4D + 1.4L_h + 1.7L$ or $1.1D + 1.1L_h + 1.3L + 1.2T_o$ and
$1.4D + 1.4L_h + 1.7L + 1.4P_s + 1.2T_o$

b. Abnormal: $1.0D + 1.0L_h + 1.0L + 1.4P_s + 1.2T_a$

c. Extreme environmental: $1.0D + 1.0L_h + 1.0L + 1.0T_o + 1.0E_s$

d. Abnormal/extreme environmental: $1.0D + 1.0L_h + 1.0L + 1.0P_s + 1.0T_a + 1.0E_s$

P_s is the air-clearing load, which is the hydrodynamic load generated by the expulsion of air in POSRV discharge lines during the POSRV discharge following the water clearing phenomena in the sparger.

3.8A.1.4.3.2.3 Analysis Methods and Results

The IRWST FEM is part of the containment internal structure full model. See Subsection 3.8A.1.4.3.1.3. The governing load to the IRWST outer wall and upper slab is the sparger discharge load. Hydrodynamic loads occur at two sparger locations (north and west). Therefore, stresses on the portions of outer wall and upper slab are investigated and critical sections are selected where the largest stress takes place. The design forces and moments for IRWST critical sections are presented in Table 3.8A-19.

Table 3.8A-40 presents the margins of safety of rebar and concrete stresses in the IRWST. The margin of safety is the ratio of allowable stress and actual stress.

The typical rebar arrangements for the IRWST are presented in the Table 3.8A-23.

3.8A.1.4.3.2.4 Conclusion

The IRWST wall/slab concrete section strengths determined from the criteria in ACI 349 are sufficient to resist the design basis loads. It is feasible to design and construct the structural components considered. The assumptions envelop the given parameters so the design is adequate for any site-specific conditions within the parameters.

b. Abnormal: $1.0D + 1.0L_h + 1.0L + 1.4P_a + 1.2T_a$

c. Extreme environmental: $1.0D + 1.0L_h + 1.0L + 1.0T_o + 1.0E_s$

d. Abnormal/extreme: $1.0D + 1.0L_h + 1.0L + 1.0P_a + 1.0T_a + 1.0Y_r + 1.0E_s$

3.8A.1.4.3.3.3 Analysis Methods and Results

The SSW FEM is a part of the containment internal structure full model. See Subsection 3.8A.1.4.3.1.3. The SSWs extend from El. 100 ft 0 in up to the operating floor at El. 156 ft 0 in. The SSW from El. 100 ft 0 in to El. 114 ft 0 in is selected as the critical section because this portion of the wall includes the junction between SSW and fill concrete.

The refueling pool walls extend from the bottom of the pool at El. 130 ft 0 in up to El. 156 ft 0 in. The north, south, and west walls between these elevations are selected as critical sections.

SG enclosure walls extend from El. 156 ft 0 in up to El. 191 ft 0 in, which is the top of wall. SG enclosure walls between these elevations are selected as critical sections.

PZR enclosure walls extend from El. 133 ft 4 in up to El. 200 ft 0 in, which is the top of wall. PZR enclosure walls from El. 156 ft 0 in up to 191 ft 0 in are selected as critical sections since these portions of the wall support the PZR laterally. The design forces and moments for SSW critical sections are presented in the Table 3.8A-20. Table 3.8A-25 presents the margins of safety of rebar and concrete stresses ~~stress~~ in secondary shield wall. The margin of safety is the ratio of allowable stress and actual stress.

3.8A.1.4.3.3.4 Typical Rebar Arrangement

The typical rebar arrangements for the SSW are presented in the Table 3.8A-23.

3.8A.1.4.3.3.5 Conclusion

The SSW concrete section strengths determined from the criteria in ACI 349 are sufficient to resist the design basis loads. It is feasible to design and construct the structural

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and Concrete Table 3.8A-4 (1 of ~~2~~) and Dome

Rebar Stresses and Margins of Safety for RCB Wall Design Sections

Wall-Basemat Junction Area (Rebar)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
41.7	35.3	43.2	53.2	32.2	36.1	28.8	51.4
Ratio (1)				Ratio (1)			
1.29	1.53	1.25	1.18	1.68	1.50	1.88	1.05

Mid-Height Level of Wall (Rebar)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
46.8	33.8	38.4	45.6	39.4	33.6	31.2	50.2
Ratio (1)				Ratio (1)			
1.15	1.60	1.41	1.18	1.37	1.61	1.73	1.08

Polar Crane Bracket Level and Springline (Rebar)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
27.2	18.5	16.4	47.4	43.1	22.4	36.1	43.5
Ratio (1)				Ratio (1)			
1.99	2.92	3.29	1.14	1.25	2.41	1.50	1.24

Table 3.8A-4 (2 of ~~2~~ 4)

Dome (Rebar)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
4.5	22.9	2.6	50.1	20.0	31.3	15.7	50.3
Ratio (1)				Ratio (1)			
12.00	2.36	20.77	1.08	2.70	1.73	3.44	1.07

Equipment Hatch (Rebar)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
39.4	38.9	39.0	54.0 (2) (ε=0.00192)	40.2	32.9	37.9	48.9
Ratio (1)				Ratio (1)			
1.37	1.39	1.38	1.00	1.34	1.64	1.42	1.10

Move

Personnel Airlock (Rebar)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
31.7	37.9	28.7	54.0 (2) (ε=0.00192)	51.3	45.6	43.5	53.0
Ratio (1)				Ratio (1)			
1.70	1.42	1.88	1.00	1.05	1.18	1.24	1.02

(1) Ratio = allowable stress ($0.9F_y$) / actual stress

(2) The reinforcement meets the requirement of Subarticle CC-3422.1 of the ASME Code.

Table 3.8A-4 (3 of 4)

Wall-Basemat Junction Area (Concrete)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
-2.5	-2.1	-2.5	-2.2	-1.0	-0.9	-2.3	-0.9
Ratio (3)		Ratio (4)		Ratio (3)		Ratio (4)	
1.77	2.16	2.00	2.32	4.47	5.09	2.26	5.41

Mid-Height Level of Wall (Concrete)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
-1.9	-1.8	-2.5	-1.8	-2.4	-1.7	-2.5	-1.6
Ratio (3)		Ratio (4)		Ratio (3)		Ratio (4)	
2.33	2.49	2.00	2.90	1.91	2.66	2.00	3.26

Polar Crane Bracket Level and Springline (Concrete)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
-1.5	-1.5	-2.5	-1.5	-2.5	-1.6	-2.6	-1.6
Ratio (3)		Ratio (4)		Ratio (3)		Ratio (4)	
3.02	2.96	2.06	3.46	1.84	2.83	2.00	3.25

Table added

Table 3.8A-4 (4 of 4)

Equipment Hatch (Concrete)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
-2.3	-1.7	-2.6	-1.7	-1.5	-1.3	-2.5	-1.3
Ratio (3)		Ratio (4)		Ratio (3)		Ratio (4)	
1.95	2.60	2.00	3.04	2.95	3.50	2.08	4.00

Personnel Airlock (Concrete)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
-2.4	-1.9	-2.5	-1.7	-2.0	-0.8	-2.3	-0.5
Ratio (3)		Ratio (4)		Ratio (3)		Ratio (4)	
1.91	2.39	2.00	2.97	2.29	5.76	2.21	9.38

Dome (Concrete)

Meridional				Hoop			
Mechanical		Mech. + Thermal		Mechanical		Mech. + Thermal	
Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
-1.4	-1.0	-2.4	-0.9	-1.0	-0.9	-2.2	-0.9
Ratio (3)		Ratio (4)		Ratio (3)		Ratio (4)	
3.19	4.72	2.10	5.65	4.31	4.79	2.29	5.76

(3) Ratio = allowable compression stress for mechanical load (0.75 f'_c) / actual stress

(4) Ratio = allowable compression stress for mechanical plus thermal load (0.85 f'_c) / actual stress

Table added

Rebar and Concrete

Table 3.8A-10

Flexural ~~Reinforcement~~ Stresses and Margins of Safety for RCB Basemat

Rebar

Design Section	Service Load Combination			Factored Load Combination		
	Allowable Stress (ksi)	Maximum Stress (ksi)	Ratio(1)	Allowable Stress (ksi)	Maximum Stress (ksi)	Ratio(1)
Section-01	30.00	27.13	1.11	54.00	40.76	1.32
Section-02		24.06	1.25		22.99	2.35
Section-03		12.46	2.41		17.35	3.11
Section-04		10.51	2.85		39.18	1.38
Section-05		14.08	2.13		53.46	1.01
Section-06		7.47	4.02		30.52	1.77
Section-07		7.25	4.14		36.09	1.50
Section-08		10.94	2.74		50.83	1.06

(1) Ratio = Allowable stress / Maximum Stress

S

Table added

Concrete

Design Section	Service Load Combination			Factored Load Combination		
	Allowable Stress (ksi)	Maximum Stress (ksi)	Ratio(1)	Allowable Stress (ksi)	Maximum Stress (ksi)	Ratio(1)
Section-01	2.25	1.527	1.47	3.75	2.039	1.84
Section-02		0.782	2.88		0.306	12.25
Section-03		0.677	3.32		0.691	5.43
Section-04		0.261	8.62		0.814	4.61
Section-05		0.338	6.66		1.276	2.94
Section-06		0.000	-		0.000	-
Section-07		0.234	9.62		0.015	250.00
Section-08		0.571	3.94		1.046	3.59

Table 3.8A-22

Margins of Safety for Primary Shield Wall

Rebar

Section	~~Meridional Section~~ Meridional/Vertical Direction			~~Hoop Section~~ Hoop/Horizontal Direction		
	Stress (ksi)		Ratio [1]	Stress (ksi)		Ratio [1]
	Allowable	Rebar		Allowable	Rebar	
North Wall	54	32.3	1.67	54	41.9	1.29
East Wall	54	32.7	1.65	54	43.2	1.25
South Wall	54	32.0	1.69	54	34.1	1.58

(1) Ratio = Allowable ~~s~~tress / ~~Rebar~~ Stress

S Maximum

Table added

Concrete

Location	Meridional/Vertical Direction			Hoop/Horizontal Direction		
	Stress (ksi)		Ratio [1]	Stress (ksi)		Ratio [1]
	Allowable	Concrete		Allowable	Concrete	
North Wall	3.57	1.11	3.20	3.57	1.00	3.56
East Wall	3.57	1.23	2.90	3.57	0.97	3.68
South Wall	3.57	1.10	3.24	3.57	0.89	4.02

Table 3.8A-25

Margins of Safety for Secondary Shield Wall

Rebar

Structure	Meridional/Vertical ~~Section~~ Direction			Hoop/Horizontal ~~Section~~ Direction		
	Stress (ksi)		Ratio (1)	Stress (ksi)		Ratio (1)
	Allowable	Rebar		Allowable	Rebar	
SSW	54	38.6	1.39	54	40.3	1.34
Refueling Pool North/South	54	52.1	1.04	54	51.3	1.05
Refueling West	54	36.8	1.47	54	43.6	1.24
SG Circular	54	46.5	1.16	54	47.1	1.15
SG Straight	54	51.7	1.04	54	49.1	1.10
PZR	54	37.7	1.43	54	42.3	1.28

(1) Ratio = Allowable Stress / ~~Rebar~~ Maximum Stress

Table added

Concrete

Location	Meridional/Vertical Direction			Hoop/Horizontal Direction		
	Stress (ksi)		Ratio (1)	Stress (ksi)		Ratio (1)
	Allowable	Concrete		Allowable	Concrete	
SSW	3.57	0.82	4.34	3.57	1.07	3.35
Refueling Pool North/South	3.57	2.52	1.42	3.57	1.98	1.81
Refueling West	3.57	0.41	8.71	3.57	0.24	14.63
SG Circular	3.57	2.12	1.68	3.57	2.09	1.71
SG Straight	3.57	3.28	1.09	3.57	1.97	1.81
PZR	3.57	1.12	3.19	3.57	2.13	1.68

Table 3.8A-40

Margins of Safety for In-containment Refueling Water Storage Tank

Rebar

Location	Meridional/Vertical Direction			Hoop/Horizontal Direction		
	Stress (ksi)		Ratio (1)	Stress (ksi)		Ratio (1)
	Allowable	Rebar		Allowable	Rebar	
Top slab	54	45.35	1.19	54	18.179	2.97
Outer Wall	54	2.858	18.89	54	30.463	1.77

Concrete

Location	Meridional/Vertical Direction			Hoop/Horizontal Direction		
	Stress (ksi)		Ratio (1)	Stress (ksi)		Ratio (1)
	Allowable	Concrete		Allowable	Concrete	
Top slab	3.57	0.75	4.76	3.57	0.442	8.07
Outer Wall	3.57	0.56	6.375	3.57	0.000	-

(1) Ratio = Allowable Stress / Maximum Stress

Table Added

LIST OF TABLES