3.8.3.1.11 Interior Concrete Fill Slab

The interior concrete fill slab is located on the surface of liner plate of the reactor containment building basemat for protection of pressure boundary structures.

3.8.3.1.12 Polar Crane Supports

A large capacity of polar crane is supported by brackets installed in the containment shell, and the bracket is a steel structure consisting of cantilever beam.

3.8.3.2 Applicable Codes, Standards, and Specifications

The following codes, standards, and specifications are applied to the design of internal concrete and steel structures.

3.8.3.2.1 Design Codes and Standards

The design codes, standards, and regulations are listed in Table 3.8-1.

3.8.3.2.2 NRC Regulatory Guides

Conformance to each NRC RG is described in Section 1.9. The NRC RGs applicable to the design of the concrete and steel structures are 1.60, 1.61, 1.92, 1.122, 1.142, and 1.199 (References 22 through 27).

3.8.3.2.3 Industry Standards

Nationally recognized industry standards, such as those published by ASTM, will be used whenever possible to describe material properties, testing procedures, and fabrications and construction methods.

3.8.3.3 Loads and Load Combinations

The typical loads and load combinations ~~used for the internal structures~~ are ~~detailed~~ described in Subsection 3.8.4.3.

The internal structures are designed for the following loads:

a. Dead load

b. Equipment operating loads and other live loads

c. Pipe reactions

d. Seismic load

e. Internal missiles (the internal structure is designed to withstand internal missiles, as described in Section 3.5)

f. Pipe rupture jet impingement

g. Compartment accident pressure

h. The greatest pipe rupture loads from (1) pipe breaks not eliminated by leak-before-break, (2) the largest through-wall leakage crack in a high-energy line (minimum 37.9 L/min (10 gpm)), whether or not consideration of dynamic effects is eliminated by leak-before-break for the line, or (3) the largest leak from another leak source, such as a valve or pump seal.

i. Operating and accident temperatures

Seismic Category I concrete structures are designed for impulsive and impactive loads in accordance with the ACI 349 Code, and special provisions of Appendix C of the same code, with exceptions given in NRC RG 1.142. Impactive and impulsive loads are considered concurrent with seismic and other loads (i.e., dead and live loads) in determining the load resistance of structural elements.

Subcompartment pressure loads are the result of postulated high-energy pipe ruptures. In determining an appropriate equivalent static load for $Y_r$, $Y_j$, and $Y_m$, elasto-plastic behavior is acceptable with appropriate ductility ratios, provided excessive deflections do not result in loss of function of any safety-related system.

Insert the paragraph in the next page

j. Hydrostatic and dynamic loads (IRWST)

Miscellaneous loads (Mo, Ma), wind loads (W), precipitation loads (H, Hs), and tornado loads (Wt) of the loads in DCD Table 3.8-9A are not affect to the design of the containment internal structures (CIS). Because the CIS is protected by the concrete containment and there is no column, transformer, belt and etc. Therefore, these loads are not applied to the design of the CIS.
Crane and trolley loads (C), jet impingement loads (Yj), missile impact loads (Ym) of the loads in DCD Table 3.8-9A are considered in local affected area.
Reactions of pipe, cable tray and duct support (Ro) and accident reactions of pipe, cable tray and duct support (Ra) are evaluated in local affected area after the load information are provided from the supplier.
Flooding loads (Yf) is not applied because it is offset by acting equally on both sides of the CIS.
During operation, there is no pressure or little pressure act on the CIS. But, accident pressure (Pa) is conservatively applied to design of the CIS instead of operating pressure (Po).

3.8A.1.4.3 Internal Structures

3.8A.1.4.3.1 Primary Shield Wall

3.8A.1.4.3.1.1 Description

The PSW is a massive rectangular concrete structure, 18.80 m (61 ft 8 in.) long by 11.43 m (37 ft 6 in) wide, with cavities consisting of the following:

a. Vertical chase, 2.03 m (6 ft 8 in.) by 5.18 m (17 ft 0 in.), for in-core instrumentation (ICI) guide tubes from the seal table at the bottom of the refueling pool, El. 130 ft 0 in, down to the bottom of the ICI tunnel at El. 69 ft 0 in.

b. Horizontal chase, 5.51 m (18 ft 3/4 in.) wide 4.27 m (14 ft 0 in.) high, from below the seal table to below the reactor vessel for the ICI guide tubes.

c. A cavity to enclose and support the reactor vessel from the top of the PSW at El. 130 ft 0 in to the bottom of the ICI horizontal chase.

d. Openings to allow installation and access to the main coolant loop piping from the reactor vessel to the steam generators and the RCPs back to the reactor vessel.

e. A laydown area for the upper guide structure that is a part of the fuel handing system. This opening is 5.18 m (17 ft 0 in.) by 5.16 m (16 ft 11 in.) and extends from the bottom of the refueling pool down to El. 106 ft 6-3/8 in.

3.8A.1.4.3.1.2 Load Combinations Considered

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

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

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.1.4.3.1.3 Analysis Methods and Results

The containment internal concrete structures are interconnected at various elevations. Significant lateral loads from the reactor coolant system (RCS) supports are applied at several elevations. In order to properly account for the load distribution in structures, an overall structural model representing containment internal concrete structures is prepared. Operating concrete floor slabs are modeled to mass in a finite element model (FEM), such as slabs between the SSWs and containment shell.

The ANSYS program is used to perform structural analysis using the containment internal structure full model. The FEM consists of a total of 50,496 nodes. The numbers of shell, solid, and beam elements are 5,522, 41,689, and 827, respectively. The following containment internal structures are included in the analysis model:

Solid Elements

a. PSW

b. IRWST and fill concrete

Shell Elements

a. SSW

b. Refueling pool wall and slab

c. Pressurizer (PZR) enclosure wall and slab

d. Steam generator (SG) enclosure wall

e. Operating floor slab between SSW and refueling pool wall

Crane and trolley loads (C), jet impingement loads (Yj), missile impact loads (Ym), reactions of pipe, cable tray and duct support (Ro), and accident reactions of pipe, cable tray and duct support (Ra) are not act on the PSW. So, these loads are not applied to the design of the PSW.

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~~ and $1.1D + 1.1L_h + 1.3L + 1.2T_o$ 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.

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.

3.8A.1.4.3.3 SSW

3.8A.1.4.3.3.1 Description

The SSW is a circular reinforced concrete structure that extends up to the main operating floor. The wall is anchored to the containment basemat. The wall is integrally connected to the refueling pool at the fuel transfer tube side (east) and at the regenerative heat exchanger room (west). At other points, the SSW is connected to the refueling pool through the SG and PZR enclosure walls and RCP lateral support members, which make the SSW and the internal structures almost symmetric around the east-west centerline of the containment.

In addition to enclosing the primary loop and the internal structures, the SSW provides lateral support for the SGs, RCPs, PZR, and the operating and intermediate floors inside the containment.

The major floor elevations are as follows:

a. Base floor: El. 100 ft 0 in

b. Intermediate floor: El. 114 ft 0 in, El. 136 ft 6 in

c. Operating floor: El.156 ft 0 in

The major design dimensions of the secondary shield wall are as follows:

a. Wall thickness: 1.22 m (4 ft)

b. Inside radius: 14.94 m (49 ft)

c. Height of wall: 17.07 m (56 ft)

3.8A.1.4.3.3.2 Load Combinations Considered

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

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

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: $1.0D + 1.0L_h + 1.0L + 1.0P_a + 1.0T_a + 1.0Y_r + 1.0E_s$

Crane and trolley loads (C), jet impingement loads (Yj), missile impact loads (Ym), reactions of pipe, cable tray and duct support (Ro), and accident reactions of pipe, cable tray and duct support (Ra) are evaluated in local affected area.

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 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