SUPPLEMENTAL 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.:	**129-8085**
SRP Section:	**03.08.01 – Concrete Containment**
Application Section:	**3.8.1**
Date of RAI Issue:	**08/05/2015**

Question No. 03.08.01-1

Appendix A to 10 CFR Part 50, General Design Criteria1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the concrete containment. Standard Review Plan (SRP) 3.8.1, Section II.3 discusses the loads and load combinations normally applicable to concrete containments with emphasis on the extent of compliance with Article CC-3230 of Section III, Division 2, of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, with additional guidance provided in Regulatory Guide 1.136, "Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments."

APR1400 DCD Tier 2, Section 3.8.1.3, "Loads and Load Combinations," states that the containment is designed to resist the loads given in the ASME Code and RG 1.136 with some exceptions. The staff reviewed the information pertaining to the applicable design loads and various combinations provided by the applicant and noticed that additional information is needed in order for the staff to complete its evaluation. In accordance with SRP 3.8.1, and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, the applicant is requested to address the following and include this information in the DCD:

a. Provide a description for other loads which are included in the load combinations presented in DCD Table 3.8-2, but are not defined in DCD Section 3.8.1.3.2, i.e., G, H, H_s, and P_s, as well as D_d, L_h, and C which are identified in the footnotes to the table.

b. In DCD Section 3.8.1.3.2, the seismic load (E_s) is defined as loads generated by the safe shutdown earthquake (SSE) in which only the actual dead loads and live loads are considered in evaluating seismic response forces. Since it is not clear whether full live load or a portion of the live load is considered when evaluating the seismic response forces in design, provide this information and the basis for that approach. This seismic inertial live load would be in addition to the separate live load used in the applicable load combinations.

c. DCD Section 3.8.1.3, item b, describes the load combination associated with the combustible hydrogen generation due to fuel clad metal-water reaction. Identify what is the pressure calculated for this loading condition and if it is greater than 45 psig, what pressure is used in the design.

d. In DCD Table 3.8-2, "Seismic Category I Structure Load Combination for the Reactor Containment Building," it is not clear why both load combinations (LCs) 13 and 14 were provided with the only difference being that in LC 13, W is included and in LC 14, W is omitted. KHNP is requested to explain whether they followed the approach that if any load reduces the effects of other loads, then that load is omitted. The use of LC 13 and 14 suggests that this approach may not have been followed.

e. Explain where in DCD Sections 3.8.1.3 and 3.8.3.3 the load descriptions and load combinations for consideration of safety/relief valve actuation loads on the containment and containment internal structures are described and whether or not the safety/relief valve actuation loads include potential direct loads on the structures and potential building dynamic response loads.

f. DCD Section 3.8.1.3 does not describe the safety/relief valve actuation load, if applicable, and the method used for combining dynamic loads that include SSE, LOCA and safety/relief valve actuation. Provide this information and indicate if it is in accordance with SRP 3.8.1 (including Appendix A) and Regulatory Guide (RG) 1.136, "Materials, Construction, and Testing of Concrete Containments," Revision 3.

Response – (Rev. 2)

a. Loads G, H, H_s, P_s, D_d, L_h, and C are defined as follows;

- Valve actuation load (G)

  Loads resulting from relief valve or other high energy device actuation

- Design flood/precipitation load (H)

  Flood loads on seismic Category I structures are determined based on the maximum site flood levels specified in DCD Tier 2, Chapter 2.

- Probable maximum flood/precipitation (H_s)

  H_s is the forces, due to the probable maximum precipitation as well as the maximum flood level, which includes the effects of seiches, surges, waves, and tsunamis.

- Combustible gas load (P_s)

  The pressure loads during an accident that releases hydrogen generated from 100 percent fuel clad metal-water reaction accompanied by hydrogen burning are combined together. The combustible gas load is described in Subsection 19.2.4.2.1 in detail.

1) Fuel clad metal-water reaction pressure – P_{g1}

   Pressure loads from 100 percent fuel clad metal-water reaction

2) Hydrogen combustion pressure – P_{g2}

   Pressure loads from hydrogen combustion

- Self-weight of structure (D_d)

  D_d is the load from the self-weight of the structure, including waterproofing, siding, and insulation.

- Hydrostatic load (L_h)

  Hydrostatic loads are due to weight and pressures of fluids with well-defined densities and controllable maximum heights.

- Crane and Trolley Loads (C)

  This load is the crane and trolley lifted load, including impact load, longitudinal load, and lateral load. All of these loads shall be considered as acting simultaneously. This load is described in detail in DCD Tier 2, Subsection 3.8.4.3.1.

Loads G, H, H_s, P_s, and C will be described in DCD Tier 2, Subsection 3.8.1.3.2. Loads D_d and L_h are currently defined in Table 3.8-8; pointers will be added to the applicable notes of Table 3.8-2. DCD Tier 2, Subsection 3.8.1.3.2 and Table 3.8-2 will be revised as shown in the Attachment 1 associated with this response.

b. When evaluating seismic response forces, only 75 percent of design snow load is applied to the containment dome, in accordance with SRP 3.7.2, Section II.3.D since the effect of seismic live load on the slabs of the containment building is insignificant according to the response to RAI 252-8299, Question 03.07.02-7_Rev.2.

   To clarify the design floor live load in the containment, DCD Tier 2, Subsection 3.8.1.3.2 and 3.8A.1.4.3.1.3 will be revised as shown in the Attachment 1 associated with this response.

c. The pressure of P_s (P_{g1}+P_{g2}) is determined by using the adiabatic, isochoric, complete combustion (AICC) pressure evaluation. Based on the results of this evaluation, the upper-bound value for the pressure load as a result of slow deflagrations of hydrogen produced from 100 percent metal-water reaction is 109 psig.

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The details regarding the AICC pressure and sensitivity analysis are described in the calculation note "Assessment of AICC Pressure Load due to Hydrogen Combustion in Containment during Severe Accident." is the calculation note has been uploaded in the electronic reading room (ERR). In addition, DCD Tier 2, Subsection 3.8.1.3 and 3.8.1.3.2 will be revised, as indicated in the Attachment 1 associated with this response.

d. If any load reduces the effects of other loads, that load is omitted in the design. Load combination (LC) 13 in Table 3.8-2 will be omitted as indicated in the Attachment 1 associated with this response since LC 13 is less severe than LC 14. The load combinations in Table 3.8-2 are in accordance with ASME CC Table 3230-1. However, OBE seismic load E_o was omitted per DCD Tier 2, Subsection 3.7.1.

e. DCD Tier 2, Subsection 3.8.1.3 does not describe pilot-operated safety relief valve (POSRV) actuation load since POSRV actuation loads are not applied on the containment wall. The IRWST is separated from the containment wall by a gap of 2 inches, as shown in Figure 1 below. Thus, there is no connection to transfer POSRV actuation loads to the containment wall. Therefore, POSRV actuation loads are not applied to the containment basemat through the containment wall. DCD Tier 2, Subsection 3.8.3.1.8 will be revised, indicated in the Attachment 1 associated with this response.

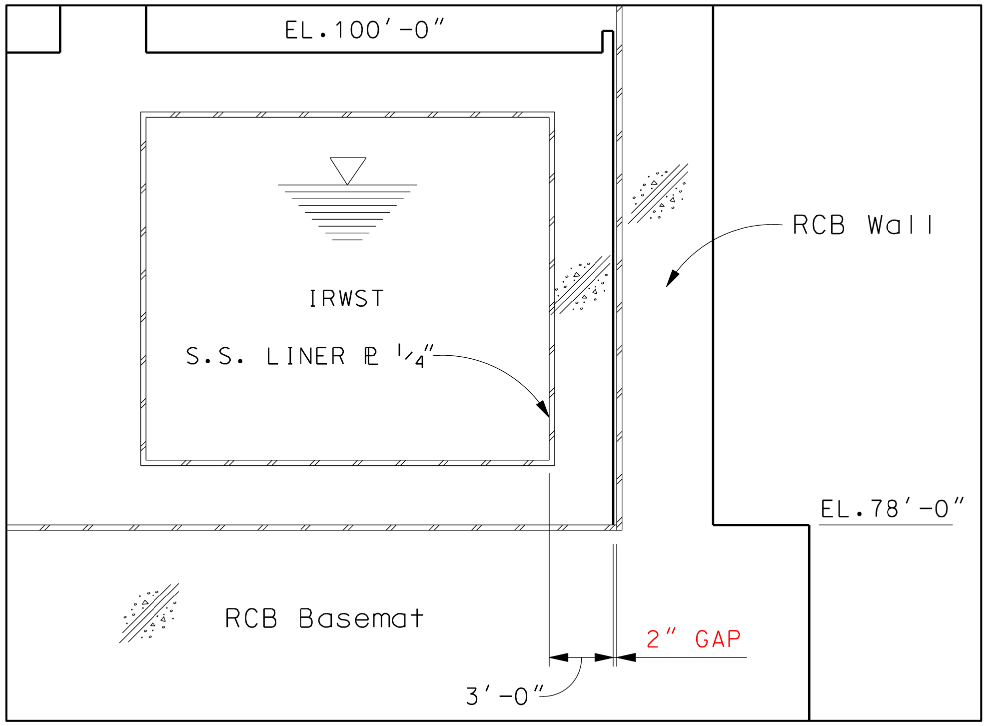

Figure 1 Section of Containment around IRWST

For the containment internal structures, POSRV actuation loads are transmitted through the pressurizer (DCD Tier 2, Subsection 3.8.3.1.4 and 3.8A.1.4.3.1.3). Therefore, the loads are treated as a kind of reactor coolant system (RCS) support load. For RCS support loads, the governing load, either POSRV actuation or branch line pipe break (BLPB) load, has been applied on the pressurizer enclosure room wall and slab.

For POSRV discharge load, a hydrodynamic pressure which is generated by the explosion of air during POSRV discharge, is applied to the wall and bottom slab of the IRWST through the 12 spargers (DCD Tier 2, Subsection 3.8A.1.4.3.1.3). This hydrodynamic pressure load is a short transient pressure time history during the expansion and collapse of the air bubble. The air bubble transient pressure time history is directly applied to the wall and bottom slab of the IRWST using the normalized factor which is considered for the distance between the spagers and structures.

For the ARP 1400 IRWST design, the hydrodynamic pressure load generated by the spargers due to POSRV actuation is determined to be 21.2 psi which is added the approximately 40% margin. The hydrodynamic considering the dynamic impact factor is applied as an equivalent static pressure loading to the submerged IRWST wall and bottom boundaries. Details of the hydrodynamic pressure load generated by the spargers are described in the response to Question 03.08.03-1 of RAI No. 208-8245.

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f. DCD Tier 2, Subsection 3.8.1.3 does not describe POSRV actuation load since the POSRV actuation loads are not applied on the containment wall. The POSRV load is only applied to IRWST mentioned above. The IRWST is not pressure boundary structure. Therefore, the approach described in Appendix A to SRP Section 3.8.1 is not applicable to the APR1400 plant.

   For your reference, the definition and description of the POSRV load on the IRWST, which includes the load in the applicable load combinations, and method for combining the POSRV load with other loads, were already described in DCD Tier 2 Subsection 3.8A.1.4.3.1.3, 3.8A.1.4.3.2.2 and 3.8A.1.4.3.2.3.

Supplemental Questions and Responses

Clarification Questions Related to Treatment of Live Load in the Structural Design Section 3.8 (September 20, 2016 ; October 25, 2016 ; November 15, 2016)

The KHNP response to RAI 8299, Question 3.7.2-7 addresses questions raised by the NRC regarding the treatment of live loads in the seismic models. There are some questions related to the structural models and structural design related to live loads that should also be explained. Therefore, provide clarification for the items listed below.

1. DCD 3.8.3.3, “Loads and Load Combinations,” indicates that typical loads and load combinations used for internal structures are detailed in Subsection 3.8.4.3. DCD Section 3.8.4.3 states: “Live load refers to any normal loads that may vary with intensity and location of occurrence. The types and definitions of live loads and their combination requirements are given in Table 3.8-8. The specified design values for live loads are summarized in Table 3.8-7.”

   The response to RAI 8085, Question 3.8.1-1 provides markups to revise the above definition of live load to state “Live loads generated by any moveable equipment during construction and maintenance of plant.” In view of the resolution to RAI 8299, Question 3.7.2-7, which will not rely on the assumption that a seismic event does not occur during construction and maintenance of the plant and thus live loads in some cases do not need to be included in the seismic analysis, the markup for live load given in RAI 8085, Question 3.8.1-1 should not be implemented and the original live load definition in the DCD should remain.

   RESPONSE (October 11, 2016 - ERR Upload)
   The original definition of live load in DCD Subsection 3.8.1.3.2 will be remained as commented. To reflect the resolution to RAI 8299 Question 3.7.2-7 to DCD, Response to RAI 8085 Question 3.8.1-1 will be revised as shown on the Attachment 1 of draft revised response to RAI 129-8085 Question 03.08.01-1 (Rev.2).

2. The following items relate to DCD Table 3.8-7 referred to in the definition of live load in DCD Section 3.8.4.3.

(a) The table indicates that for "Main floor at elevation 78 ft 0 in to 174 ft 0 in, live load is "10.0 (200) ~" and "24.0 (500)" with the number in parenthesis representing psf. Explain, why there are two live loads of 200 psf and 500 psf, what they represent, and what structures and slabs they are applicable to. For example, the "Main floor at elevation 78 ft 0 in to 174 ft 0 in" appears to be only applicable to the containment internal structures and probably the containment, and not the AB, EDGB, and DFOT.

RESPONSE (October 11, 2016 – ERR Upload)
To consider normal live load and the equipment removal load, these two live loads are described in the DCD Table 3.8-7. The normal live load is 200psf and equipment removal load is 500 psf respectively (refer to DCD 3.8A.2.3.1). The footnote for these two live loads will be added in the DCD Table 3.8-7 and the description "Main floor at elevation 78 ft 0 in to 174 ft 0 in" will be changed to "Main floors" as shown in the Attachment 2.

The title of DCD Table 3.8-7 will be changed to "Design Loads for Seismic category I Structures" as shown in the Attachment 2 since this table shall be applied all seismic category I structures except Reactor Containment Structure.

(b) Besides the two separate entries for the basemat, and the cask loading and decontamination pit which have different live loads, does the 200 psf / 500 psf entry include the live load associated with any heavy equipment where applicable on all other slabs?

RESPONSE (October 11, 2016 - ERR Upload)
As mentioned above feedback(a), 500 psf is used for the equipment removal area. That means heavy equipment load is considered basically. If any other equipment load is larger than this load, actual equipment load shall be used to design.

3. The following items relate to DCD Table 3.8-8 referred to in the definition of live load in DCD Section 3.8.4.3.

(a) This table identifies six types of live loads: L_h (hydrostatic) L_g (weight and pressure of soil), L_s (snow), L_f (floor and roof), L_o (operating reaction of equipment excluding D_e (weight of equipment)) and L_e (occupancy load for concrete and steel galleries during SSE). However, Table 3.8-9A, which is the load combination table for reinforced concrete structures excluding the containment, only identifies L and L_h. Confirm whether L in DCD Table 3.8-9A includes all five of the other live loads in DCD Table 3.8-8. Similarly, in DCD Table 3.8-9B, which is applicable to seismic Category I steel structures, only L is identified, and so does this term include all six types of live loads identified in DCD Table 3.8-8.

RESPONSE (October 11, 2016 – ERR Upload)
The live load "L" in DCD Table 3.8-9A includes five loads except L_h in DCD Table 3.8-8 and the live load "L" in DCD Table 3.8-9B include all six types of live loads identified in DCD Table 3.8-8. The footnote will be added in the DCD Table 3.8-9A and Table 3.8-9B for clarification as shown in the Attachment 3.

(b) For L_e, explain what “concrete and steel galleries” correspond to as compared to L_f (floor and roof live loads), why is the term “occupancy” used in which case live load of 50 psf is defined, and does the phrase “during the SSE” mean that the real live load is 200 psf and 25% of this equaling 50 psf is therefore used in the structural model for determining the SSE load due to live load in addition to the dead load being accelerated by the SSE.

RESPONSE (November 21, 2016)
As shown in the Attachment 4, the description of L_e in the DCD Table 3.8-8, “occupancy load~“, will be changed for “seismic live load~” to clarify the description and this load is applied same area where L_f is applied.

The specified normal live load (L_f) and seismic live load (L_e) is shown below table. 25% of normal live load is considered in the structural analysis of each building to represent the seismic live load. 25% of normal live load was considered in the load combination including safe shutdown earthquake (E_s) as a mass to calculate the seismic inertial forces and 100% of normal live load was considered in the other load combinations for structural analysis. However the slab is not modeled in the structural analysis model of containment and internal structure, the normal live load (considering slab area) is applied at the connecting point of slab to the structural analysis model. In case of seismic live load, however the load is not considered in the structural model, the mass ratios of seismic live load/containment and internal structure are only 0.06% and 0.4%, respectively. Therefore the seismic live load does not have a significant effect on the overall building response.

Building	Normal Live Load (psf)		Seismic Live Load (psf)	
	Floor	Roof	Floor	Roof
Auxiliary Building	200	100	50	NOTE 2
EDGB	200	100	50	NOTE 2
Containment	200, 1000	N/A	NOTE 1	N/A
Internal Structure	200, 1000	N/A	NOTE 1	N/A

Note
1) Seismic live load was not considered in the structural analysis of containment and CIS. Although the seismic live load was not included in the overall structural analysis for the containment and CIS, it was included in the local analysis and design of the floors.
2) Conservatively 50 psf was considered in the structural analysis instead of 25 psf.

3.(b)1 The question in the first sentence of 3.(b) was not addressed. It requested the following: “For L_e, explain what “concrete and steel galleries” correspond to as compared to L_f (floor and roof live loads).” Please explain what does “concrete and steel galleries” mean and how are they different than L_f?

RESPONSE (November 14, 2016)

L_e is used for the same area where L_f is applied to as explained in the first response "~ this load is applied same area where L_f is applied." To avoid confusion, the description "concrete and steel galleries" will be revised to "Floor and roof" as shown in Attachment 4.

3.(b)2 In the first sentence of the paragraph highlighted above, the applicant stated that “Usually 25% of normal live load is in the structural analysis of each building.” Does that mean that 25% of the normal live load is in the structural analysis of each building to represent the seismic live load? If so, then revise the sentence accordingly. Also, this should be a separate sentence from the remaining phrases in the sentence that follow it to avoid confusion.

RESPONSE (November 14, 2016)

The 25% of normal live load is applied to structural analysis to represent the seismic live load. And the sentence was revised accordingly as shown above.

3.(b)3 In the first sentence of the paragraph highlighted above, the applicant stated that “100% of seismic live load was considered as a mass to calculate the seismic inertial forces.” Does that mean that 100% of the seismic live load (which is 25% of the live load)? If so, then revise the sentence accordingly.

RESPONSE (November 14, 2016)

The confusing expression (100% of seismic live load) was deleted and the sentence was revised accordingly as shown above.

3.(b)4 In reviewing Table 3.8-8 in Attachment 4, which appears to be applicable to all seismic Category I structures, the staff noticed that the floor and roof live loads (L_f) were not included in some of the loading conditions. This is inconsistent with the first sentence of the paragraph highlighted above, which states “100% of normal live load was considered for structural analysis and 100% of seismic live load was considered as a mass to calculate the seismic inertial forces.” This is also inconsistent with the load combination tables shown in DCD Tables 3.8-2, 3.8-9A, and 3.8-9B, where live load (presumably including floor and roof live loads) is included in all load combinations. Please confirm that L_f was considered in all load combinations and revise Table 3.8-8 accordingly, or provide a technical basis for not including L_f in the analysis for certain loading conditions.

RESPONSE (November 21, 2016)

Seismic live load (L_e, which is 25% of normal live load) was considered in the load combination including safe shutdown earthquake (E_s) and the floor and roof live load (L_f) was considered in all load combinations for structural analysis. The sentence was revised accordingly as shown above and DCD Table 3.8-8 will be revised as shown in Attachment 4.

3.(b)5 In the second sentence of the paragraph highlighted above, the applicant indicated that the structural analysis of the containment and containment internal structures (CIS) are conservative based on the two ratios of the seismic live load vs the containment and the CIS. The staff believes that these two ratios have been shown to be small, and thus should not have a significant effect on the overall building response; however, it has not been shown to be “conservative.” This should be revised accordingly or provide the technical basis for concluding it is conservative.

The staff also notes that the first paragraph refers to “…is conservative enough if considering the comparison of response spectrum analysis and time history analysis as shown in Table 1 of RAI No. 183-8197 Q. 03.07.02-2.” This study does not show that neglecting seismic live load is conservative, but rather its effect on the overall building seismic response, in terms of ISRS, is negligible. In addition, Note 1 above states “Although the seismic live load was not considered, the comparison in Table 1 of RAI No. 183-8197 Q. 03.07.02-2 shows the conservatism of containment and internal structure analysis and design.” The staff notes that Table 1 only shows a comparison of the fundamental frequencies between the slabs in the coarse and fine mesh RCB models. That does not provide a comparison of the building or slab responses and it does not show any conservatism in not considering seismic live load.

As discussed above, the two ratios (seismic live load vs the global mass of the containment and the CIS) only show that the effect of not including the seismic live load in the structural building analysis does not affect the overall building seismic response (i.e., ISRS). However, for the local analysis and design of the floors, the seismic live load should be considered because its effect is not expected to be negligible, or KHNP should provide the technical basis for not including seismic live load in the local analysis/design of the floors. It should be noted that even if the seismic input (e.g., response spectra) to the containment or CIS is unaffected by not including live load, if an additional mass for live load is included in the local analysis/design of the slabs, then the member forces for design of the slabs will be larger.

RESPONSE (November 21, 2016)

The additional discussion related to RAI No. 183-8197 Q.03.07.02-2 were deleted and explanation for the seismic live load considered in the local analysis and design of the floors were added to the text and Note as shown above.

3.(b)6 In Note 1 above, the applicant stated, “Seismic live load was not considered in the structural analysis.” Does that mean the seismic LL was not included in the modeling of the slabs in the overall building analysis and also in the local analysis and design of the slabs? This note should be revised accordingly.

RESPONSE (November 14, 2016)

Seismic live load was not included in the modeling of the slabs in the overall building analysis but included in the local analysis and design of the slabs. The sentence was supplemented as shown above.

3.(b)7 The Table in the RAI response above indicates for the containment, no seismic live load is considered for the floors and roof. This appears to be inconsistent with the markup shown in the Attachment 1, page 4/12, applicable for the containment which defines the seismic load as follows: “k. Seismic Load (E_s) Loads generated by the SSE; only the actual dead loads and, 25 percent of live load or 75 percent of snow are considered in evaluating seismic response forces.” Please explain the apparent inconsistency.

RESPONSE (November 14, 2016)
Basically seismic live load (L_e) should be considered in evaluating seismic response forces. The Attachment 1(RAI 129-8085 Q 03.08.01-1_Rev.2), page 4/12, described the basic concept of seismic and structural analysis, however seismic live load was not considered in the structural analysis of containment and CIS as indicated in the footnote of the Table in this response.
Although the seismic live load was not considered in the structural analysis of containment and CIS, the effect on the design of the structures is not significant since the mass ratios (L_f/containment and L_f/CIS) are negligibly small. And the comparison in Table 1 of RAI No. 183-8197 Q. 03.07.02-2 shows that the story shear force of RSA method is larger than those of THA method.

3.(b)8 The information provided in the table included as part of Item 3.(b), for the normal live load and seismic live load for each of the structures, is not reflected adequately in the DCD. The markup for DCD Table 3.8-7 provided in the response presents some of this information but not all. For example (but not a complete list): (1) the table in the RAI response provides live loads for each building separately while the markup for Table 3.8-7 now does not identify the structures and but does indicate in the title that it excludes the reactor containment building, (2) the table in the RAI response indicates 1,000 psf presumably for heavy equipment in the RCB and no heavy equipment load in the AB and EDGB while Table 3.8-7 indicates 500 psf presumably for the AB and EDGB, and (3) live loads for the roof slabs are not consistent between the two tables. KHNP is requested to include the information provided in the table of the RAI response along with appropriate footnotes and explanations in the DCD in some manner and make corrections to DCD Table 3.8-7 as necessary.

RESPONSE (November 14, 2016)
The DCD Table 3.8-7 will be revised to coincide with RAI response table as shown in Attachment 2 and the description "1000 psf" will be added in footnote (5) of DCD Table 3.8-7 for heavy equipment load on AB CVCS roof area to consider SG removal as well. This heavy equipment load(1000 psf) is not applied on EDGB. The description of live loads on roof slabs of DCD

Table 3.8-7 "2.4(50), 10.0(200)" will be changed to "4.8(100) to match with RAI response table as shown in Attachment 2.

4. For DCD Table 3.8-9A, there is a footnote (1) applicable to “D” (dead load) that states: “Where a load occurs simultaneously with and reduces effects of other loads, the load factor is taken as 0.9; otherwise, the load factor is taken as zero.” As written, this does not seem to be appropriate since it is applicable only for the dead load “D.” Explain whether this footnote should apply to the Table heading labeled “Loads” instead, in which case this footnote should apply to all loads. Also, this footnote should be made more consistent with the provision in Section 9.2.3 of ACI 349-97 which states: “For the Load Combinations in 9.2.1, where any load reduces the effects of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with the other loads. Otherwise, the coefficient for that load shall be taken as zero.” Based on the more recent ACI 349 edition, the term “coefficient” is updated to use the term “load factor.”

RESPONSE (October 11, 2016 – ERR Upload)
To consistent with ACI 349-97 Section 9.2.3, the description and application of the Footnote (1) of the DCD Table 3.8-9A will be revised as shown in the Attachment 3.

Impact on DCD

DCD Tier 2, Subsection 3.8.1.3, 3.8.1.3.2, 3.8.3.1.8, Table 3.8-2, 3.8A.1.4.3.1.3, and 3.8A.1.4.3.2.3 will be revised, as indicated in the Attachment 1 associated with this response.

DCD Tier 2, Table 3.8-7, 3.8-8, 3.8-9A, 3.8-9B will be revised as indicated in the Attachments 2, 3, and 4 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.

3.8.1.2.1 Design Codes, Standards, Specifications, and Regulations

The design codes, standards, specifications, and regulations are listed in Table 3.8-1. The primary design code for concrete containment is ASME Section III, Division 2, Subsection CC (Reference 3).

3.8.1.2.2 NRC Regulatory Guides

Conformance to each NRC Regulatory Guide (RG) is described in Section 1.9. The NRC RGs applicable to the design of the concrete containment are NRC RG 1.35 (Reference 4), NRC RG 1.35.1 (Reference 5), NRC RG 1.136 (Reference 6), and NRC RG 1.7 (Reference 7).

3.8.1.2.3 Industry Standards

Internationally recognized industry standards published by ASTM are used whenever possible to define material properties, testing procedures, and fabrication and construction methods.

3.8.1.3 Loads and Load Combinations

The containment is designed to resist the loads given in Article CC-3000 of the ASME Code and NRC RG 1.136 with the exceptions listed below.

a. The post-LOCA flooding combined with the safe shutdown earthquake (SSE) is more severe than the post-LOCA flooding combined with the operating basis earthquake (OBE) set at one third or less of the SSE for the plant. Therefore, only the post-LOCA flooding SSE combination is considered in the design.

b. Subarticle CC-3720 of the ASME Code is satisfied when the containment structure is exposed to the load combination listed below. As a minimum design condition, the pressure (P_{g1} + P_{g2}) is not less than 310 kPa (45 psig).

$D + F ~~+ T~~ + P_{g1} + P_{g2}$

Where:

D = Dead load

F = Prestress

~~T = Temperature load~~

P_{g1} = Pressure resulting from an accident that releases hydrogen generated from 100 percent fuel clad metal-water reaction

P_{g2} = Pressure resulting from uncontrolled hydrogen burning

A description of load categories and definition of loads are given in Subsections 3.8.1.3.1 and 3.8.1.3.2.

3.8.1.3.1 Load Category

The load categories include any condition encountered during construction and testing, and in the normal operation of a nuclear power plant, as well as the conditions resulting from extreme environmental conditions postulated during the life of the facility and certain combinations thereof.

The design loads are defined as service load category and factored load category depending on the frequency of their occurrence.

3.8.1.3.1.1 Service Loads

Service loads are any loads encountered during construction and in the normal operation of a nuclear power plant and include loads such as any anticipated transient or test loads during normal and emergency startup and shutdown of the nuclear steam supply, safety and auxiliary systems, and the severe environmental loads that may be anticipated during the life of the facility.

Construction

The construction condition considers events and loads during construction, including the various stages of prestressing but excluding those during testing. Contraction loads for buildings and other structures are developed in accordance with Table 3.8-2 and with SEI/ASCE 37-02 (Reference 8).

reactions due to postulated pipe breaks for design basis accidents. This loading condition also includes plant-related non-environmental missiles. The loads from each postulated accident event are considered to be mutually exclusive of other postulated accidents.

Abnormal/Severe Environmental

The abnormal/extreme condition includes a consideration of the loads due to the highly improbable simultaneous occurrence of abnormal and severe environmental loading conditions. Only the specified combinations of these conditions are considered.

Abnormal/Extreme Environmental

The abnormal/extreme condition includes a consideration of the loads due to the extremely improbable simultaneous occurrence of abnormal and extreme environmental loading conditions. Only the specified combinations of these conditions are considered.

3.8.1.3.2 Design Loads

The design loads pertaining to the design of containment are as follows:

a. Dead load (D)

Dead loads, including hydrostatic and permanent equipment loads

Deleted

~~Live loads generated by any movable equipment during construction and maintenance of plant~~

b. Live load (L)

Live loads, including any movable equipment loads and other loads that vary with intensity during each occurrence such as soil pressures

c. Prestress (F)

Loads resulting from the application of prestress, including effects resulting from the construction sequence used to post-tension the tendon

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~~75 percent of snow~~

Deleted

k. Seismic load (E_s)

Loads generated by the SSE; only the actual dead loads ~~and live loads~~ are considered in evaluating seismic response forces.

and, 25 percent of live load or 75 percent of snow

l. Tornado load (W_t)

Tornado or hurricane loading including the effects of missile impact

m. Internal flooding (H_a)

Load resulting from internal flooding other than from pipe breaks

n. Accident pressure (P_a)

Design pressure load within the containment generated by the design basis accident, based on the calculated peak pressure with an appropriate margin

o. Accident temperature (T_a)

Thermal effects and loads generated by the design basis accident including operating temperature (T_o)

p. Pipe reaction (R_a)

Pipe reaction from thermal conditions generated by the design basis accident including pipe reaction at normal operating or shutdown conditions (R_o)

q. Pipe break load (R_r)

Local effects due to the design basis accident normally include all postulated high-energy system ruptures. These loads include an appropriate dynamic load factor to account for the dynamic nature of the load. This load category includes:

1) Pipe break reaction load (Y_r)

2) ~~Combustible gas (P_{g1}, P_{g2})~~ ← Combustible gas load (P_s)

Combustible gas (P_{g1}) loads are pressure loads that result from a fuel-clad metal-water reaction followed by an uncontrolled hydrogen burn (P_{g2}) during a post-accident condition in the containment inerted by carbon dioxide. NRC RG 1.136, Regulatory Position C.5 provides the loads and load combinations acceptable for analysis and design of containment when exposed to the loading conditions associated with combustible gas. The loads and load combinations for combustible gas are provided in Subsection 3.8.1.3.

t. Missile loads other than hurricane generated or tornado-generated missiles

There are no missile loads on the containment resulting from activities of nearby military installations, turbine failures, or other causes.

← insert A (Next page)

3.8.1.~~3~~.3 Design Load Combinations

The applicable load combinations and load factors for the design of a concrete containment conform with the requirements of Article CC-3000 of the ASME Section III, Division 2. Table 3.8-2 lists the load combinations used in the design of the containment.

3.8.1.3.4 Liner Plate Loads and Load Combinations

The load combinations shown in Table CC-3230-1 of the ASME Code are applicable to the liner, except that load factors for all load cases are taken as equal to 1.0. Strains associated with construction-related liner deformations are excluded when calculating liner strains for the service and factored load combinations.

3.8.1.4 Design and Analysis Procedures

3.8.1.4.1 General

The design and analysis procedures are in conformance with the requirements of Article CC-3000 of the ASME Section III, Division 2.

insert A

u. Valve actuation load (G)
Loads resulting from relief valve or other high energy device actuation

v. Design flood/precipitation load (H)
Flood loads on seismic Category I structures are determined based on the maximum site flood levels specified in Chapter 2.

w. Probable maximum flood/precipitation (H_S)
H_S is the forces, due to the probable maximum precipitation as well as the maximum flood level, which includes the effects of seiches, surges, waves, and tsunamis.

x. Crane and trolley loads (C)
This load is the crane and trolley lifted load, including impact load, longitudinal load, and lateral load. All of these loads shall be considered as acting simultaneously. This load is detailed in Subsection 3.8.4.3.1.

3.8.3.1.8 In-Containment Refueling Water Storage Tank

The in-containment refueling water storage tank (IRWST) provides storage of refueling water, a single source of water for the safety injection and containment spray pumps, and a heat sink for the safety depressurization system. The IRWST is annular and uses the lower section of the internal structure as its outer boundary. The IRWST is lined with a stainless steel liner plate to prevent leakage. The IRWST consists of the top and bottom slab and the exterior wall. The bottom slab of IRWST rests on the reactor containment building basemat, and the top and bottom slabs are rigidly connected to the secondary shield wall. The IRWST is separated from the containment wall by a gap of 50 mm (2 in). The design of the IRWST considers pressurization as a result of the reactor containment building systems design basis accident. Refer to Section 6.8 for a description of the IRWST.

3.8.3.1.9 Holdup Volume Tank

The holdup volume tank (HVT) is a rectangular structural tank located between the primary shield wall and the IRWST inner wall. A screen is provided at the top of the HVT to prevent debris from getting into the tank. The HVT has a sump with pumps to measure the leakage rate and route the liquid to the liquid waste management system. During an accident, the water from breaks and the reactor containment building spray is collected in the HVT and overflows into the IRWST. Refer to Section 6.8 for a description of the HVT.

3.8.3.1.10 Operating and Intermediate Floors

The operating floor provides access for operating personnel functions and biological shielding. Intermediate floors provide access to equipment and components. The operating floor is located at elevation 156 ft 0 in, and intermediate floors are located at elevations 114 ft 0 in and 136 ft 6 in. These floors consist of reinforced concrete or steel grating supported by structural steel framing that spans between the containment wall and the secondary shield wall. The steel framing has a horizontally sliding connection at the containment wall side to allow axial displacement of framing due to seismic displacement and thermal expansion. Openings are provided in the floor for equipment removal.

Table 3.8-2

Seismic Category I Structure Load Combination for the Reactor Containment Building

Category / Loading Condition		No	$D^{(1)}$	$L^{(2)}$	F	P_t	G	Pa	T_t	T_o	T_a	E_s	W	Wt	R_o	R_a	Y_r	Y_j	Y_m	Y_f	H	H_s	P_v	H_a	P_s
Serv	Test	1	1.0	1.0	1.0	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Construction	2	1.0	1.0	1.0	-	-	-	-	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-
	Normal	3	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	-	1.0	-	-
Factored	Severe environmental	4	1.0	1.3	1.0	-	1.0	-	-	1.0	-	-	1.5	-	1.0	-	-	-	-	-	-	-	1.0	-	-
		5	1.0	1.3	1.0	-	1.0	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	1.5	-	1.0	-	-
	Extreme environmental	6	1.0	1.0	1.0	-	1.0	-	-	1.0	-	1.0	-	-	1.0	-	-	-	-	-	-	-	1.0	-	-
		7	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	-	1.0	1.0	-	-	-	-	-	-	-	1.0	-	-
		8	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	1.0	1.0	-	-
	Abnormal	9	1.0	1.0	1.0	-	1.0	1.5	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-
		10	1.0	1.0	1.0	-	1.0	1.0	-	-	1.0	-	-	-	-	1.25	-	-	-	-	-	-	-	-	-
		11	1.0	1.0	1.0	-	1.25	1.25	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-
	Abnormal/severe environmental	12	1.0	1.0	1.0	-	1.0	1.25	-	-	1.0	-	1.25	-	-	1.0	-	-	-	-	-	-	-	-	-
		~~13~~	~~1.0~~	~~1.0~~	~~1.0~~	~~-~~	~~1.0~~	~~-~~	~~-~~	~~1.0~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~	~~1.0~~	~~-~~
		~~14~~ 13	1.0	1.0	1.0	-	1.0	-		1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	1.0	-
	Abnormal/extreme environmental	~~15~~ 14	1.0	1.0	1.0	-	1.0	1.0	-	-	1.0	1.0	-	-	-	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-
	~~Severe Accident~~[3] Combustible Gas Control inside Containment	~~16~~ 15	1.0		1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0

(1) D_d is included in D. (in Table 3.8-8)

(2) Includes all temporary construction loads during and after construction of the containment; also includes Lh and C. (in Table 3.8-8)

(3) The strain does not exceed the values given in ASME Section III, Division 2, Table CC-3720-1.

Frame Elements

Deleted

a. RCP lateral support beam

b. RCS model

~~Live load which is generated by any movable equipment during construction and maintenance of plant is applied as follows:~~

Figure 3.8A-23 shows the full FEM for the containment internal structure. The solid element model (PSW, IRWST, and fill concrete), shell element model (SSW), and beam element model (RCS) are shown in Figure 3.8A-24.

Structure dead load consists of self-weight for PSW, SSW, RV, additional weight of floor and equipment, and dead load of RCS. Fifty percent of the weights and equipment weights on the floor between the containment shell and the SSW are assumed to be distributed to the containment shell and the SSW, respectively. The large equipment weights are applied as nodal forces at the location of equipment loads.

The live load is applied as follows:

a. Concrete slabs at El.100 ft 0 in and El.156 ft 0 in: ~~1.0 ksf~~

b. Other slabs: 0.2 ksf

0.2 ksf
(1.0 ksf for movable equipment during construction and maintenance)

Hydrostatic loads are divided by the surface pressure loads in the refueling pool and IRWST walls and bottom slabs.

An equivalent uniform temperature gradient is input directly in the ANSYS model at the appropriate nodes. The temperature profiles during normal operating condition are more severe than those of the accident condition, thus represent the limiting temperature for all the plant conditions.

Compartment pressures on RCB internal structures are result of a pipe break inside containment. The types of compartment pressures are as follows:

a. SG compartment – feedwater economizer nozzle

b. SG compartment – feedwater downcomer nozzle

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~~ twelve 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.

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

insert B (Next page)

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~~ twelve 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.

insert B

Because the IRWST is separated from the containment wall by a seismic gap and there is no connection to transfer POSRV load to the containment wall, the POSRV load is not directly applied on the containment wall. The primary and secondary shield wall (PSW and SSW) may be directly influenced by the POSRV load because this load is applied to the IRWST which is integrally connected with the PSW and SSW. However, the transient displacements of PSW and SSW due to POSRV load are comparatively small enough to be ignored. In addition, the spectral acceleration of POSRV is obtained from FRS curves which are generated from time-history analysis. The results comparing with seismic load show that the spectral acceleration by POSRV is less enough to be ignored for PSW and SSW. For reference, the developed FRS is used by other disciplines for qualification of systems and components (e.g., pipes and equipment).

Table 3.8-7 (1 of 2)

Design Loads for Seismic Category I Structures

Structures	Loadings kN/m^2 (psf)							Remarks
	Dead Load (D)	Live Load (L)	Rain and Wind (L and W)	Soil (L_g)	Fluid Pressure (L_h)	Tornado (W_t)	Temp. °F Min/Max (T_o)	
Containment Internal Structure	*	*	N/A	N/A	*	N/A	*	Notes : 1, 2, 6
Primary Shield Wall	-	-	N/A	N/A	-	N/A	-	
Operating Floor, EL. 156′-0″	-	50.0 (1,000) 10.0 (200)	N/A	N/A	N/A	N/A	-	Note : 11
Intermediate Floor, EL. 136′-6″	-	10.0 (200)	N/A	N/A	N/A	N/A	-	
Intermediate Floor, EL. 114′-0″	-	10.0 (200)	N/A	N/A	N/A	N/A	-	
Secondary Shield Wall	-	-	N/A	N/A	N/A	N/A	-	

Table 3.8-7 (2 of 2)

~~Design Loads for Nuclear Island Category I Structures~~ "Deleted"

Structures	Loadings kN/m^2 (psf)							Remarks
	Dead Load (D)	Live Load (L)	Rain and Wind (L and W)	Soil (L_g)	Fluid Pressure (L_h)	Tornado (W_t)	Temp.°F Min/Max (T_o)	
Other Seismic Category I Structure except RCB	*	*	*	*	*	*	*	Notes: 1, 2, 4, 6
Interior walls	1.0 (20)	16.8 (350)	N/A	N/A	-	N/A	-	Note 8
Exterior walls	0.5 (10)	16.8 (350)	-	-	-	-	-	Notes: 3, 7, 8
Roof slabs	-	~~2.4 (50) ~ 10.0 (200)~~ 4.8(100)	-	N/A	N/A	-	-	Notes: 3, 5, 9
~~Main floor at elevation 78 ft 0 in to 174 ft 0 in~~ Main floors	-	10.0 (200) ~ 24.0 (500)	-	N/A	-	-	-	Note 10
Basemat at elevation 55 ft 0 in	-	24.0 (500)	N/A		-	N/A	-	-
Cask loading and decontamination pit	-	~~52.7~~ 50.0 (1,000)	N/A	N/A	-	N/A	-	-

(1) The masses of all structures are included in all load combinations as dead loads.

(2) All structures are designed for seismic loads.

(3) See Subsection 3.8.4.3 for design soil loads, including groundwater, thermal loads, wind loads, tornado loads, and added live load due to precipitation.

(4) Abnormal loads due to main steam and feedwater line breaks are considered.

(5) Loads for SG removal (1000psf) are considered at elevation 156 ft 0 in CVCS area.

(6) Extreme external temperatures are evaluated to determine temperatures to be combined with extreme internal temperatures.

(7) Soil surcharge load on exterior walls due to construction loads.

(8) Live load on shear wall in horizontal (out-of-plane) direction to account for attachment loads.

(9) Snow drifts are considered for live load on lower roofs.

(10) Normal live load is 200psf and equipment removal load is 500psf.

(11) 50.0kN/m^2 (1,000psf) is for movable equipment during construction and maintenance.

Table 3.8-9A

Seismic Category I Structures Excluding Containment Structure
Reinforced Concrete – Ultimate Strength Design Load Combination Table

Loading Condition	No	Loads (1)																						Design Strength
		Normal									Severe Environmental		Abnormal								Extreme Environmental			
		D(1)	D_d	L (3)	L_h	T_o	R_o	C	P_o	M_o	W	H	P_a	T_a	R_a	Y_r	Y_j	Y_m	Y_f	$M_{=}$	E_s	W_t	H_s	
Construction	1	1.1	-	1.3	1.1	-	1.3	1.3	-	1.3	1.6	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
	2	-	0.9	-	1.1	-	-	1.3	-	1.3	1.6	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
Test	3	1.1	-	1.3	1.1	1.2	1.3	1.3	1.3	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
Normal	4	1.4	-	1.7	1.4	-	1.7	1.7	1.7	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
	5	1.1	-	1.3	1.1	1.2	1.3	1.3	1.3	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
Severe Environmental	6	1.4	-	1.7	1.4	-	1.7	1.7	1.7	1.7	1.7	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
	7	1.1	-	1.3	1.1	1.2	1.3	1.3	1.3	1.3	1.3	-	-	-	-	-	-	-	-	-	-	-	-	ACI349
	8	1.4	-	1.7	1.4	-	1.7	1.7	1.7	1.7	-	1.7	-	-	-	-	-	-	-	-	-	-	-	ACI349
	9	1.1	-	1.3	1.1	1.2	1.3	1.3	1.3	1.3	-	1.3	-	-	-	-	-	-	-	-	-	-	-	ACI349
Abnormal	10	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	1.0	-	-	-	ACI349
	11	1.0	-	1.0	1.0	-	-	1.0	-	1.0	-	-	1.4	1.0	1.0	-	-	-	-	-	-	-	-	ACI349
Extreme Environmental	12	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	1.0	-	-	ACI349
	13	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	1.0	-	ACI349
	14	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	1.0	ACI349
Abnormal/ Extreme Environmental	15	1.0	-	1.0	1.0	-	-	1.0	-	1.0	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	-	ACI349

(1) Where a load occurs simultaneously with and reduces effects of other loads, the load factor is taken as 0.9; otherwise, the load factor is taken as zero.

(2) Hydrodynamic loads associated with seismic loads are included in E_s.

(3) L includes L_g, L_s, L_f, L_o and L_e loads.

the other loads or is always present

Table 3.8-9B (1 of 2)

Seismic Category I Structures Structural Steel – Elastic Design Load Combination Table

Loading Condition	No	Loads [1]																						Design Strength[6], [7]
		Normal									Severe Environmental		Abnormal									Extreme Environmental			
		D	D_d	L (12)	T_o	S	R_o	C	P_o	M_o	W	H	P_a	T_a	R_a	Y_r	Y_j	Y_m	Y_f	M_a	E_s	W_t	H_s	
Construction	1	1.0	-	1.0	-	1.0	1.0	1.0	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.33 AISC N690
	2	1.0	-	1.0	-	-	1.0	1.0	-	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	1.33 AISC N690
	3	-	0.75	-	-	-	-	1.0	-	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	1.33 AISC N690
Test	4	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.33 AISC N690
Normal	5	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00 AISC N690
	6	1.0	-	1.0	-	1.0	-	1.0	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00 AISC N690
Severe Environmental	7	1.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	1.00 AISC N690
	8	1.0	-	1.0	-	-	-	1.0	-	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	1.00 AISC N690
	9	1.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	-	1.0	-	-	-	-	-	-	-	-	-	-	-	1.00 AISC N690
Abnormal [4], [7]	10	1.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	1.0	-	-	-	1.60 AISC N690[3], [5]
	11	1.0	-	1.0	-	-	-	1.0	-	1.0	-	-	1.0	1.0	1.0	-	-	-	-	-	-	-	-	1.60 AISC N690[3], [5]
	12	1.0	-	1.0	-	-	-	1.0	-	1.0	-	-	1.0	1.0	-	-	-	-	-	-	-	-	-	1.60 AISC N690[3], [5]
Extreme Environmental	13	1.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	1.0	-	-	1.60 AISC N690[3], [5]
	14	1.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	1.0	-	1.60 AISC N690[3], [5]
	15	1.0	-	1.0	1.0	-	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	1.0	1.60 AISC N690[3], [5]
Abnormal/ Extreme Environmental[7],[8]	16	1.0	-	1.0	-	-	-	1.0	-	1.0	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	-	1.70 AISC N690[3], [5]

Table 3.8-9B (2 of 2)

(1) All load combinations are checked for a no-live-load condition.

(2) For primary plus secondary stress, the allowable stresses are increased by a factor of 1.5.

(3) In load combinations 10 through 16, the design stress in shear is not to exceed 1.4 × AISC N690 in members and bolts.

(4) The load combination 12 is to be used when the global (non-transient) sustained effects of T_a are considered.

(5) The design stress where axial compression exceeds 20 percent of normal allowable is 1.5 × AISC N690 for load combinations 10, 11, 12, 13, 14, and 15 and 1.6 for load combination 16.

(6) In no instance does the allowable stress exceed 0.7 F_u in axial tension or 0.7 F_u times the ratio Z/S for tension plus bending.

(7) The maximum values of P_a, T_a, R_a, Y_j, Y_r and Y_m, including an appropriate dynamic load factor, is used in load combination 11, 12, and 16, unless an appropriate time-history analysis is performed to justify otherwise.

(8) In combining loads from a postulated high-energy pipe break accident and a seismic event the SRSS (square root of the sum of the squares) may be used, provided the responses are calculated on a linear basis.

(9) Secondary stresses that are used to limit primary stresses are treated as primary stresses.

(12) L includes L_h, L_g, L_s, L_f, L_o and L_e loads.

Table 3.8-8

Types and Applicable Loading Conditions for Dead Loads and Live Loads

Applicable Loading Conditions									
Construction	Test	Normal	Severe Environmental	Abnormal	Extreme Environmental	Abnormal/ Severe Environmental	Abnormal/ Extreme Environmental	Load	Definition of Loads
×	×	×	×	×				DEAD LOADS	D_h – Vertical Pressure of liquids (with due regard to variations in the liquid depth)
×	×	×	×	×					D_d – Self-weight of structure including waterproofing, siding, and insulation
	×	×	×	×					D_e – Weight of equipment and its contents (gravity load under operating conditions). This includes crane self-weights and trolley hoist self-weights.
×									D_{cn} – Shoring and other loads provided by contractor
×	×	×	×	×				LIVE LOADS	L_h – Hydrostatic loads due to weight and pressures of fluids with well-defined densities and controllable maximum height
×	×	×	×	×					L_g – Loads due to the weight and pressure of soil, water in soil, or other materials
×	×	×	×	×					L_s – Snow loads
	×	×	×	X					L_f – Floor and roof live loads
	×	×	×	×					L_o – Operating reaction of equipment excluding De
				×					L_e – 2.4 kN/m^2 (50 psf) ~~occupancy load~~ seismic live load for ~~concrete and steel galleries~~ Floor and roof during SSE loadings