REVISED 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.:	**227-8274**
SRP Section:	**03.08.04 – Other Seismic Category I Structures**
Application Section:	**SRP 3.8.4**
Date of RAI Issue:	**09/25/2015**

Question No. 03.08.04-5

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 seismic Category I structures. Standard Review Plan (SRP) 3.8.4.II.3, "Load and Load Combinations," identifies loads and load combinations that are acceptable for seismic Category I structures.

In APR1400 DCD, Tier 2, Section 3.8.4.3, "Loads and Load Combinations," the staff identified items that need to be addressed to ensure that the correct loads and load combinations are used. Therefore, the applicant is requested to address the following, and if applicable, include this information in the DCD:

a) In DCD subsection 3.8.4.3.1, "Normal Loads," the applicant identified Ro as being applicable to pipe, cable tray, duct supports, and ties. This section indicates that this load includes their dead load, live load, thermal load, seismic load, thrust load, and unbalanced internal pressure under normal and severe environmental conditions.

   Applicant is requested to explain why this definition is not consistent with the definition given in ACI 349 nor AISC N690, including Supplement 2. As an example, for ACI 349, R_o is applicable to piping and equipment (not limited to the four components given above). Also, it is applicable to normal and shutdown conditions excluding dead load and seismic load. The seismic load for piping and equipment should be under the load E_{ss}. A similar situation occurs for the definition of R_a in DCD subsection 3.8.4.3.2, "Abnormal Loads."

b) In DCD subsection 3.8.4.3.4, "Extreme Environmental Loads," the applicant identified the use of the 100-40-40 percent method which is described in ASCE 4, Subsection 3.2.7, as an alternative to the square root of the sum of the squares (SRSS) method. This section of the DCD indicates that the 100-40-40 percent rule is based on the observation that the maximum increase in the resultant for two orthogonal forces occurs when these forces are equal. The maximum value is 1.4 times one component.

Applicant is requested to explain these statements because according to ASCE 4, the 100-40-40 method is based on the assumption that when the maximum response from one component occurs, the response from the other two components are 40 percent of the maximum. Also, the DCD indicates that the 100-40-40 percent rule may also be applied for combining responses in the same direction due to different components of motion. This statement should be explained because the term “also” implies that that the 100-40-40 method covers two situations. It is the staff’s understanding that the 100-40- 40 method only applies when combining the responses acting in the same direction due to each of the three perpendicular seismic input motions. Lastly, for the 100-40-40 method, the applicant is requested to describe the approach used to determine the total response of a structural element when there is more than one response parameter, such as a column axial force and moment to be used in design. This can be exemplified by providing an example to demonstrate whether the maximum values for each response parameter is obtained first for the 24 plus and minus permutations, and then all plus and minus permutations are taken between the design parameters resulting in 2M power sets of response combinations (where M equals the number of response parameters) to be considered in design.

c) In DCD subsection 3.8.4.3.4, “Extreme Environmental Loads,” in Item 2, “Combination of SSE Loads,” the applicant stated that the stresses due to seismic loads from different directions are combined by the SRSS method using the following expression; however, no expression is provided.

Applicant is requested to provide the expression.

d) In DCD Table 3.8-9A, “Seismic Category I Structures Excluding Containment Structure Reinforced Concrete – Ultimate Strength Design Load Combination Table,” the applicant identifies a load labeled as ”$M_{=}$.”

Applicant is requested to clarify or correct this load condition.

e) In Table 3.8-9B, “Seismic Category I Structures Structural Steel – Elastic Design Load Combination Table,” the applicant identified a load “S.”

Applicant is requested to define the load “S.”

f) In Table 3.8-9B, “Seismic Category I Structures Structural Steel – Elastic Design Load Combination Table,” the applicant used a load factor 1.33 for the construction and test load combinations (numbers 1 through 4).

Applicant is requested to describe why a factor of 1.33 times the design strength was used.

g) In Table 3.8-9B, “Seismic Category I Structures Structural Steel – Elastic Design Load Combination Table,” the applicant did not provided footnotes “a and i” from Table Q1.5.7.1, “Load Combinations And Applicable Stress Limit Coefficients,” in AISC N690-94, including Supplement 2.

Applicant is to include footnotes “a and i” from Q1.5.7.1 in AISC N690-94, including Supplement 2.

h) NRC DC/COL-ISG-7, “Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures,” clarify the NRC’s position on identifying winter precipitation events as site characteristics and site parameters for determining normal and extreme winter precipitation loads on the roofs of Seismic Category I structures.

Applicant is requested to describe how the criteria of NRC DC/COL-ISG-7 were considered in the load combinations in Section 3.8.4.3.

Response – (Rev.2)

a) DCD subsection 3.8.4.3.1 d. and 3.8.4.3.2 c. definition of R_o and R_a load will be revised as shown in Attachment 1 to this response.

- Equipment, Pipe, cable, duct support and ties -(R_o)
- Accident reactions of equipment, pipe, cable, duct supports and ties-(R_a).

Please refer to the markup in Attachment 1.

ACI 349 and AISC N690 define a dead load(D) and seismic load(E_s or E_{ss})for the piping and equipment loads respectively .These loads are distinguished from R_o and combined in the loading combinations. But In DCD Subsection 3.8.4.3.1 and 3.8.4.3.4, Dead load and Seismic Loads for the piping and equipment loads are not defined separately. These loads are included in R_o and are considered in each loading combination.

Even though these loads are not separated into D and E_s (or E_{ss}) , since the load factor of R_o is equal to or larger than the dead load or seismic load factor(refer to Table 3.8-9A), those results are equal to or more conservative than the ACI 349 or AISC N690 load combination results.

DCD Subsection 3.8.4.3.2, “Abnormal Loads,” load R_a is the same situation as R_o.

b) The earthquake responses for all three directions are combined simultaneously. There are two methods to combine the directional responses, the square root of the sum of the squares (SRSS) method and the 100-40-40 percent rule described in ASCE 4, Subsection 3.2.7.

For the analysis of seismic Category I structures of APR1400, the SRSS method was selected to combine the independent directional responses of the SSE in order to obtain the maximum seismic response for design. The 100-40-40 percent rule was used for the basemat analysis to combine independent directional loads from superstructures. Therefore, Subsection 3.8.4.3.4 and 3.8.5.3 will be revised as shown in Attachment 2 to this response.

c) The following equation was unintentionally omitted from DCD Tier 2, Subsection 3.8.4.3.4. Therefore, Subsection 3.8.4.3.4 will be revised to complete the description regarding the SRSS method, as shown in Attachment 3 to this response.

$$R = \pm\sqrt{\sum_i R_i^2}$$

Where R is any response of interest and Ri (i=1, 2, 3) is the two horizontal components and one vertical component of earthquake motion.

d) This is typo. This typo will be corrected to "M_a" as shown in Attachment 4 to this response.

e) There is no stability load (S) described in loads and load combinations for Seismic Category I structural steel of AISC N690. Therefore, Table 3.8-9B will be revised to remove the load "S" as shown in Attachment 5 to this response.

f) There is no provision in American Society of Civil Engineers (ASCE) 37-02, "Design Loads on Structures during Construction," that allows for the one third increases in allowable stress.

Therefore, Table 3.8-9B will be revised to have a load factor of 1.00 for items 1 through 4 in Table 3.8-9B, as shown in Attachment 6 to this response.

g) Table 3.8-9B (2 of 2) will be revised to identify footnotes "a and i" in AISC N690, as shown in Attachment 7 to this response.

h) In the APR 1400 design, the criteria of NRC DC/COL-ISG-7 are not considered in the load combinations in Section 3.8.4.3. (Refer to the response of RAI 126-8012 Q.02.03.01-4)

Impact on DCD

DCD Tier 2, Subsections 3.8.4.3.1, 3.8.4.3.2, 3.8.4.3.4, 3.8.5.3 and Tables 3.8.9A and 3.8-9B will be revised as indicated 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.

normal loading condition is 12.0 kN/m^2 (250 psf). Any loading conditions that result in soil surcharge loads greater than these minimum values are checked on an individual basis.

2) Hydrostatic load (L_h)

Hydrostatic loads are due to weight and pressures of fluids with well-defined densities and controllable maximum heights or related internal moment and forces.

3) Snow load (L_s)

Based on the assumed site-related parameters, the 100-year snowpack roof load is considered to be 2.873 kN/m^2 (60 psf).

c. Thermal operating load – (T_o)

Thermal operating load is thermal load effect from the most critical transient or steady-state thermal condition at normal operation or shutdown conditions. This also includes thermal effects such as frictional loads due to expansion.

d. ~~Pipe, cable tray, duct supports, and ties – (R_o)~~

Equipment, pipe, cable tray, duct supports and ties– (R_o)

This includes their dead load, live load, thermal load, seismic load, thrust load, and unbalanced internal pressure under normal and severe environmental conditions.

R_{os} – Self-weights, including contents

R_{ot} – Transient or steady-state thermal loading conditions during normal operation and shutdown conditions

For the test loading condition, this includes piping reactions due to test cleanup and blowdown conditions.

R_{op} – Effects of unbalanced pressure and thrust construction. SEI/ASCE 37-02 (Reference 8) is considered to be supplemental guidance.

3.8.4.3.2 Abnormal Loads

a. Accident pressure – (P_a)

Accident pressure is applied to external or internal air, gas, or liquid pressure loads during abnormal operating conditions. Examples of this are excursion pressures within gas ducts due to fan or damper type failures and differential air pressure on a building wall due to a postulated pipe break including annulus pressurization effects and flooding loads. An appropriate dynamic factor to account for the dynamic response of the structure and the time dependency of the load is included.

1) Main steam valve house

The compartmental accident pressures due to main steam and feedwater line breaks are considered.

2) Other areas

Accident pressures in other areas of seismic Category I structures are defined during plant layout and design.

b. Accident temperature – (T_a)

Accident temperature is thermal load effects during abnormal operating conditions. Accident temperatures in other areas of seismic Category I structures are defined during plant layout and design.

c. ~~Accident reactions of pipe, cable tray and duct supports and ties – (R_a)~~

Accident reactions of equipment, pipe, cable tray, duct supports and ties – (R_a)

R_a is reactions of pipe, cable tray, and duct supports and ties. This includes their dead load, live load, thermal load, seismic load, thrust load, and transient

c. Operating basis earthquake

The operating basis earthquake (OBE) is defined as one-third of the SSE. Therefore, an analysis or design of APR1400 seismic Category I SSCs based on OBE is not required in accordance with Appendix S of 10 CFR Part 50.

3.8.4.3.4 Extreme Environmental Loads

a. Safe shutdown earthquake – (E_s)

SSE loads are considered as follows:

1) Seismic Category I structures

For seismic Category I structures, E_s are the loads generated by the SSE. Hydrodynamic load and dynamic soil pressure are included in E_s.

Seismic response for SSE is determined using a dynamic analysis. Enveloped floor response spectra in both the horizontal (N-S and E-W) and vertical directions are prepared for all major building floor elevations. An equivalent static method is used to determine SSE loads on structural components (e.g., floor slabs, beams).

2) Combination of SSE loads

For each load, the responses from all three directional earthquakes are combined simultaneously. The independent directional responses are combined using the square root of the sum of the squares (SRSS) method or the 100-40-40 percent rule described in ASCE 4, Subsection 3.2.7. ~~The 100-40-40 percent rule is based on the observation that the maximum increase in the resultant for two orthogonal forces occurs when these forces are equal. The maximum value is 1.4 times one component. All possible combinations of the three orthogonal responses are considered. The 100-40-40 percent rule may also be applied for combining responses in the same direction due to different components of motion.~~ For the auxiliary building and the EDG building, the square root of sum of the square method was used to combine the SSE loads.

The auxiliary building basemat is reinforced at the top and bottom with layers of reinforcing steel bars. The reinforcing bars are arranged in orthogonal directions for the top and bottom layers.

3.8.5.1.3 Emergency Diesel Generator Foundations

The emergency diesel generator (EDG) building block comprises two buildings, one of which houses the EDGs and the other the diesel fuel oil tank (DFOT). The two buildings are independent structures built on a separate concrete reinforced mat foundation with a thickness of 1.2 m (4 ft). The bottom of the basemat is located at elevation 92 ft 0 in for the EDG building and elevation 59 ft 0 in for the DFOT building.

3.8.5.2 Applicable Codes, Standards, and Specifications

The reinforced concrete foundations of the reactor containment building are designed using the codes and standards described in Subsection 3.8.1.2. The reinforced concrete foundations and supports of other seismic Category I structures are designed using the codes and standards described in Subsection 3.8.4.2.

3.8.5.3 Loads and Load Combinations

The design loads and load combinations of the reactor containment building foundation are described in Table 3.8-2. The design loads and load combinations of the auxiliary building foundation and EDG building foundation are described in Subsection 3.8.4.3.

For combining SSE loads, the 100-40-40 percent rule was used for the basemat analysis to combine independent directional loads from superstructures, in accordance with ASCE 4, Subsection 3.2.7. The 100-40-40 percent rule is based on the observation that the maximum increase in the resultant for two orthogonal forces occurs when these forces are equal. This rule may be applied for combining responses in the same direction due to different components of motion.

3.8.5.4 Design and Analysis Procedures

The NI common basemat is analyzed using the ANSYS computer program. Stiffening effects of the reactor containment building wall, internal concrete structures, and auxiliary building are included in the model.

The NI common basemat is modeled with eight-node solid element in the ANSYS computer program. In addition, in order to consider the soil effect, the link element in ANSYS is used with the NI common basemat model.

Stresses due to seismic loads from different directions are combined by the SRSS method using the following expression:

$$R = \pm \sqrt{\sum_i R_i^2}$$

Where R is any response of interest and Ri (i=1, 2, 3) is the two horizontal components and one vertical component of earthquake motion.

3) Additional seismic loads due to accidental torsion

Additional seismic loads due to accidental torsion are accounted for as required by SRP Subsection 3.7.2.II.11. An additional eccentricity of the mass at each floor equivalent to 5 percent of the maximum building dimension is included. The accidental torsion load is represented by an additional shear force at each floor elevation determined from the analysis for the product of resultant story shear and accidental eccentricity at each elevation.

b. Tornado or hurricane load – (W_t)

The tornado or hurricane loads are described in Subsection 3.3.2.

c. 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.

3.8.4.3.5 Other Loads

Other loads are loads resulting from aircraft hazard and explosion pressure wave that are not included in the design basis. These loads are evaluated to prevent damage to safety-related structures, systems, and components beyond the design basis condition.

3.8.4.3.6 Load Combinations

The load combinations to be used in the design of the structure are in accordance with Tables 3.8-9A and 3.8-9B, and in conjunction with the definitions of load conditions and design loads as provided in Subsections 3.8.4.3.1 through 3.8.4.3.5.

Table 3.8-9A

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

Loading Condition	No	Loads																						Design Strength
		Normal									Severe Environmental		Abnormal								Extreme Environmental			
		$D^{(1)}$	D_d	L	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~~ Ma	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.

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	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]

Delete Load "S"

Table 3.8-9B (1 of 2)

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

1.00 AISC N690

Loading Condition	No	Loads (1)																						Design Strength (6), (7)
		Normal									Severe Environmental		Abnormal								Extreme Environmental			
		D	D_d	L	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 (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	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 [10, 11]	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.

(10) Consideration shall also be given to snow and other loads as defined in ASCE 7.

(11) Allowable stress limits coefficients are applied to the basic stress allowable of AISC. The coefficients for AISC N690 are supplemented by the requirements identified in subsection 3.8.4.5.

Added