REQUEST FOR ADDITIONAL INFORMATION 342-2000 REVISION 0

4/21/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.08.04 - Other Seismic Category I Structures
Application Section: 3.8.4

QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)

03.08.04-1

3.8.4-1

In DCD Subsection 3.8.4.1, the first paragraph (Page 3.8-45) states, “Adjoining building basemats are structurally separated by a 4 in. gap at and below the grade. This requirement does not apply to engineered mat fill concrete that is designed to be part of the basemat subgrade for the interface between the R/B, and east and west PS/Bs. To be consistent with seismic modeling requirements of Section 3.7, no 4 in. gap is permitted in the fill concrete between these buildings.”

The applicant is requested to provide the following information:

(a) Provide a description for the engineered mat fill concrete, including its dimensions and thickness and concrete strength.

(b) The last sentence of the above quote states that “To be consistent with … no 4 in gap is permitted …” What are the specific seismic modeling requirements of DCD Section 3.7 that make it necessary to eliminate the 4 in. gap between basemats of certain buildings?

03.08.04-2

3.8.4-2

DCD Section 3.8.4.1, the second paragraph (Page 3.8-45) states, “The minimum gaps between building superstructures is two times the absolute sum of the maximum displacement of each building under the most unfavorable load combination, or a minimum of 4 in.”

The applicant is requested to provide the following information:

How was the maximum displacement of each building calculated? Was it based on the elastic analysis? Per ASCE/SEI 7-05 Section 12.8.6, this displacement needs to be amplified by the deflection amplification factor, C_d. Was the deflection amplification factor considered in your calculation? If yes, what is the value used. If not, provide the technical basis for not using it. Also, was the effect of the differential settlement at the basemat included in the maximum displacement calculation?

03.08.04-3

3.8.4-3

In DCD Subsection 3.8.4.1.1, the second paragraph (Page 3.8-45) states, “The R/B consists of the following five areas, defined by their functions.

- PCCV and containment internal structure
- Safety system pumps and heat exchangers area
- Fuel handling area
- Main steam and feed water area
- Safety-related electrical area”

The applicant is requested to provide the following information:

(a) PCCV and containment internal structures are not part of the R/B. Clarify the above quoted statement of the first bullet.

(b) Provide floor plans for each of the four areas in the above list (excluding the PCCV and containment internal structure).

03.08.04-4

3.8.4-4

In DCD Subsection 3.8.4.3.2, the first paragraph (Page 3.8-49) states, “Hydrodynamic loads due to seismic sloshing are calculated per ASCE Standard 4-98....”

The applicant is requested to provide the following information:

Were the hydrodynamic loads associated with the impulsive mode included? (Note that impulse mode is that mode in which a portion of the water moves in unison with the tank, wall, and is not due to sloshing.) If yes, provide information for how they were calculated. If not, explain why they were not considered.

03.08.04-5

3.8.4-5

In DCD Subsection 3.8.4.3.3, it (Page 3.8-50) states, “The dynamic soil pressure, induced during an SSE event, is considered as an earthquake load E_{ss}.”

The applicant is requested to describe how the dynamic soil pressure, $E_{ss,}$ was calculated. Was the soil considered as fully saturated to account for ground and flood water levels?

03.08.04-6

3.8.4-6

The subject of DCD Subsection 3.8.4.3.4 is live loads and different live loads are listed from DCD Subsection 3.8.4.3.4.1 to DCD Subsection 3.8.4.3.4.9.

The applicant is requested to provide the following information:

There is no roof live load in the list. Per ASCE 7-05 (note that ASCE 7-05 is listed in subsection 3.8.4.2 as one of the Applicable Codes, Standards, and Specifications for US-APWR), roof live load is a load on roof produced during maintenance by workers, equipment and materials, and a minimum roof live load in addition to the snow load should be specified and included in the analysis. Provide a rationale for not including any roof live load, or to specify the magnitude of roof live load.

03.08.04-7

3.8.4-7

In DCD Subsection 3.8.4.3.4.7, the second paragraph (Page 3.8-52) states, "Impact allowance for traveling crane supports and runway horizontal forces are in accordance with AISC N690 (Reference 3.8-9) for seismic category I and II structures, unless the crane manufacturer's design specifies higher impact loads. The vertical live load is increased by 25% to account for vertical impact of cab-operated traveling cranes and 10% of pendant-operated traveling cranes. A lateral force, equal to 20% of the lifted load and crane trolley are applied at the top and perpendicular to the crane rails. A longitudinal force equal to 10% of the maximum wheel load is applied at the top of the rails."

The applicant is requested to provide the following information:

(a) Per AISC N690, the crane runway shall also be designed for crane stop forces. Explain why these impact forces were not included.
(b) Provide information for the deflection criteria used for the crane runway.

03.08.04-8

3.8.4-8

In DCD Subsection 3.8.4.3.6.2, the second paragraph states that, "In addition to the dead load, 25% of the floor live load during normal operation or 75% of the roof snow load, whichever is applicable, is also considered as accelerated mass in the seismic models."

The applicant is requested to provide the following information:

For the live load to be considered in the seismic model, ASCE 4-98 subsection C3.1.4.2 (Page 64) refers to the Earthquake Loads Section of ASCE Standard 7. Item 4 of subsection 12.7.2 (Page 128) of ASCE 7-05 states that 20% of the roof snow load shall be included if the roof snow load exceeds 30 psf. This snow load should be added to the 25% of the live load (note that this is “and” not “or”). Provide the technical basis for not following the ASCE recommendation.

03.08.04-9

3.8.4-9

In DCD Subsection 3.8.4.3.4.3, the first paragraph (Page 3.8-51) states, “Roof rain load is accounted for in accordance with Chapter 8 of ASCE 7-05…Subsection 3.4.1.2 provides additional discussion of design features to limit ponding of rain on the roofs of plant buildings.”

The applicant is requested to provide the following information:

In DCD Subsection 3.4.1.2, it is stated that sloped roofs are designed to preclude roof ponding. What is the value of the roof slope specified in the design?

03.08.04-10

3.8.4-10

In DCD Subsection 3.8.4.3.6.2, the third paragraph (Page 3.8-53) gives a load combination equation which is shown below.

$$1.0D+(1.0L \text{ or } 0.75\ S)+ a_v\,(D+0.5\ (L \text{ or } S))$$

The applicant is requested to (1) explain the meaning of a_v (vertical seismic acceleration) and its value, and (2) provide the technical basis for this equation.

03.08.04-11

3.8.4-11

In DCD Subsection 3.8.4.4.1, the fourth paragraph (Page 3.8-56) states, “Seismic forces are obtained from the dynamic analysis of the three-dimensional lumped-mass stick model described in Subsection 3.7.2. These loads are applied to the linear elastic FE model fixed at elevation 3 ft. 7 in. as equivalent static forces."

The applicant is requested to provide the following information:

(a) Seismic forces obtained from the dynamic analysis of the 3-D lumped-mass stick model are in the time domain. Explain how forces in the time history response are converted to equivalent static forces.
(b) Where are the equivalent static forces applied at the FE model? Are these concentrated forces or distributed stresses? Explain how the equivalent static forces from the lumped-mass stick model are mapped into the 3-D Finite Element model .
(c) Provide the technical basis for using the fixed base boundary condition at elevation 3 ft, 7 in. for the FE model; whereas, the seismic forces are obtained from the dynamic analysis of the three-dimensional lumped-mass stick model that is elastically supported at the base.

03.08.04-12

3.8.4-12

In DCD Subsection 3.8.4.4.1, the sixth paragraph (Page 3.8-56) states, "The R/B is analyzed using a three-dimensional FE model with the NASTRAN computer codes (Reference 3.8-13)."

The applicant is requested to provide the following information:

(a) Were the upper bound and lower bound values of elastic modulus and shear modulus of concrete suggested by ASCE 4-98 (Subsection C3.1.3.1 in Page 63) used in the FE analyses? If not, provide the technical basis that shows your results for both the floor response spectra and the design of the R/B are conservative.
(b) Were the cracked sections of concrete considered in the analyses as suggested in Design and Analysis Procedure 4B of SRP 3.8.4 (page 3.8.4-10 of SRP 3.8.4 Revision 2, March 2007)? If not, provide the reason for not doing it.
(c) Provide information for the types of element used in the FE model.

03.08.04-13

3.8.4-13

In DCD Subsection 3.8.4.4.1.1, it (Page 3.8-57) states that South interior wall of R/B (Section 2) is one of the most highly stressed shear walls.

The applicant is requested to provide the following information:

a. What is the load or load combination that causes the high stress?
b. Is the south interior wall of R/B the highest stressed shear wall? If not, which is the highest stressed shear wall?
c. Has the stress exceeded the cracking stress of concrete in the highest stressed shear wall? If yes, was the model re-analyzed by using the cracked moment of inertia for that shear wall? If not, provide the reason for not doing it.

03.08.04-14

3.8.4-14

In DCD Subsection 3.8.4.4.1.2, the first paragraph (Page 3.8-57) states that, "The shear walls are used as the primary system for resisting lateral loads, such as earthquakes."

The applicant is requested to provide the following information:

DCD Figures 3.8.4-4 to 3.8.4-7 (Pages 3.8-202 to 3.8.205) show vertical cross section views of the shear walls with re-bar layout. Provide the corresponding horizontal cross section views of these shear walls with the re-bar layout.

03.08.04-15

3.8.4-15

In DCD Subsection 3.8.4.4.2.1, the first paragraph (Page 3.8-59) states that the West PS/B is the worst case configuration and contains the most critical sections.

The applicant is requested to provide the following information:

Explain why the West PS/B is the worst configuration, and why the East PS/B is better. Why are they not the same? As shown in Figures 1.2-2 and 1.2-3, the East PS/B and West PS/B appear to be symmetric.

03.08.04-16

3.8.4-16

In DCD Subsection 3.8.4.4.3, the sixth paragraph states, “Lateral earth pressure is calculated in accordance with ASCE 4-98 (Reference 3.8-34) for both active and passive earth pressures.”

The staff was unable to find the information for calculating the passive earth pressure in ASCE 4-98. Provide the section number of ASCE 4-98 where the guideline for calculating the passive earth pressure is given.

03.08.04-17

3.8.4-17

In DCD Subsection 3.8.4.5, "Structural Acceptance Criteria", the first paragraph (Page 3.8-62) states, “Structural acceptance criteria are listed in Table 3.8.4-3 for concrete structures and in Table 3.8.4-4 for steel structures,…….”

DCD Tables 3.8.4-3 and 3.8.4-4 are the load combinations for concrete structures and steel structures, respectively. These two tables were mentioned in DCD Subsection 3.8.4.3.9 (Page 3.8-55) with the title of "Load Combinations". The staff was unable to locate tables providing the structural acceptance criteria as stated in DCD subsection 3.8.4.5. The applicant is requested to provide information for the structural acceptance criteria.

03.08.04-18

3.8.4-18

In DCD Subsection 3.8.4.6.1.3, the second paragraph (Page 3.8-64) states, “Placement of concrete reinforcement is in accordance with ACI-349, Section 7.7 (Reference 3.8-8).”

The applicant is requested to provide the following information:

The title for ACI-349 Section 7.5 is “Placing reinforcement”. The title for ACI-349 Section 7.7 is “Concrete protection for reinforcement”. Which section, 7.5 or 7.7, was actually followed?

03.08.04-19

3.8.4-19

In DCD Subsection 3.8.4.6.3, the paragraph (Page 3.8-68) states, “There are no special construction techniques utilized in the construction of other seismic category I structures.”

The applicant is requested to describe what construction techniques and provisions are needed to address issues related to the use of the massive concrete pour of the basemat, such as the heat generated, the volume changes associated with the massive concrete pour, and the concrete cracking control.

03.08.04-20

3.8.4-20

In DCD Subsection 3.8.3.4, the fifth paragraph (Page 3.8-38) states, "For thermal loads, design forces are calculated by multiplying the reduction ratio α, considering the reduction of stiffness by cracking to the result values of above analysis. The reduction ratio α is set to 0.5 as the reduction ratio of flexural stiffness caused by cracking for the typical member. For example, the flexural stiffness of cracked section for 48 in. wall with 0.5 in. plates assuming zero tensile strength of concrete is 22.2 by 10^9 lbs-in.^{2}/in., and the reduction ratio calculated by this value and elastic flexural stiffness (47.5 x 10^9 lbs-in.^{2}/in.) is 0.47."

The applicant is requested to provide the following information:

(a) The example given above indicated that α is 0.47 for 48-in walls. What are the values of α for the 56-in and 39-in walls? Provide justification for using 0.5 for all three walls.
(b) α is the reduction ratio for the flexural stiffness. DCD Table 3.8.3-4 (Page 3.8-92) indicates that the same value of α, 0.5, was applied to the axial stiffness and shear stiffness as well in the analyses. Provide the technical basis and data to show that the reduction factors for the axial stiffness and shear stiffness are 0.5.
(c) Provide test data that substantiate the values of the reduction factor α as stated.

03.08.04-21

3.8.4-21

DCD Subsection 3.8.4.7,"Testing and Inservice Inspection Requirements", (Page 3.8-68) did not discuss any requirements for monitoring of settlement and differential displacements that are mentioned in SRP 3.8.4, Section I.7. In DCD Subsection 3.8.5.4.4,"Analysis of Settlement" (Page 3.8-73) states that, "The potential for foundation subsidence, or differential displacement, is designed for a maximum 2 in......"

The applicant is requested to provide the rationale why monitoring of settlement and differential displacement is not included in testing and inservice inspection requirements?

03.08.04-22

3.8.4-22

In DCD Subsection 3.8.4.6.1.4,"Splices", the last sentence (Page 3.8-64) states, "Welding of reinforcing steel, other than in the PCCV, is performed in accordance with American Welding Society (AWS) D1.4 (Reference 3.8-46)."

The applicant is requested to provide the following information:

In SRP Section 3.8.4, subsection I.6.B (Page 3.8.4-6 of SRP 3.8.4, Revision 2, March 2007), It is stated that, “If welding of reinforcing bars is proposed, it should comply with American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code (Code) Section III, Division 2. Any exception to compliance should be supported with adequate justification.” Are the requirements of American Welding Society D1.4 the same as those of the ASME Code Section III, Division 2? If not, provide justification for this exception.

03.08.04-23

3.8.4-23

In DCD Subsection 3.8.4.6.1.1,”Concrete”, only 4,000 psi concrete is included in the description. However, this subsection is referred by the DCD Section 3.8.5.6 for the material information used in the foundations. DCD Tier 2, Table 3.8.5-2 (page 3.8-108) indicates that in the basemat 7,000 psi concrete is used at the upper part of Tendon Gallery. The 7,000 psi concrete should be included in Subsection 3.8.4.6.1.1. Also include the codes and standards that 7,000 psi concrete needs to be in compliance with.

03.08.04-24

3.8.4-24

In DCD Subsection 3.8.4.6.1.7,”Masonry Walls”, it (Page 3.8-67) states, “A non safety-related masonry wall exists in the spray pump room located at the lowest level of the R/B, which is not subjected to pressure loads and is restrained against seismic accelerations to preclude damage to safety-related SSCs.”

The applicant is requested to provide the following information:

Describe how the masonry is restrained against seismic accelerations. Provide information to show that the restraint works. What are the nearby safety-related SSCs?

03.08.04-25

3.8.4-25

In DCD Subsection 3.8.4.2,”Applicable Codes, Standards, and Specifications”, the first paragraph (Page 3.8-48) provides a list of the codes and standards that are applicable to other seismic category I structures. The staff compared this list with the codes, standards, guides, and specifications listed in SRP Section 3.8.4.II.2, and noted that RGs 1.69, 1.91, 1.115, 1.127, 1.142, 1.143, 1.160, and 1.199 are not included in the list.

The applicant is requested to include these RGs in DCD Subsection 3.8.4.2 according to SRP 3.8.4.III.2.

03.08.04-26

3.8.4-26

In DCD Subsection 3.8.4.4,"Design and Analysis Procedures", the last sentence of the first paragraph (Page 3.8-55) states, "Table 3.8.4-5 summarizes the modeling and analytical methods of R/B and PS/Bs." In DCD Table 3.8.4-5 (Page 3.8-99), the first column is "Computer Program and Model", and the first row is "Three-dimensional NASTRAN FE of R/B model fixed at elevation 3 ft, 7 in."; the second row is "Three-dimensional NASTRAN FE of R/B whole model".

The applicant is requested to provide the following information:

(a) Why not use the R/B whole model in the first row case?
(b) What is the boundary condition for the second row case? Does the R/B whole model include soil springs?

03.08.04-27

3.8.4-27

DCD Subsection 3.8.4.2,"Applicable Codes, Standards, and Specifications" (Page 3.8-47), lists ACI 318-99 and ACI 349-01 that are applicable for Other Seismic Category I Structures (Section 3.8.4). Also, DCD Subsection 3.8.4.2 is referred by DCD Subsection 3.8.3.2 (Page 3.8-34), the applicable codes, standards, and specifications for the Concrete and Steel Internal Structures of Concrete Containment (Section 3.8.3, Page 3.8-30).

The applicant is requested to provide the following information:

Identify the seismic Category I structure or structural elements that are designed in accordance with the requirements of ACI 318-99 Code, but not with ACI 349-01 Code. Provide the rationale for choosing the ACI 318-99 Code instead of ACI 349-01 Code.

03.08.04-28

3.8.4-28

In DCD Subsection 3.8.4.4.3,"Other Seismic Category I Structures", the fourth paragraph (Page 3.8-61) states: "Members that are subject to torsion and combined shear and torsion are evaluated to the standards of Section 11.6 of ACI 318-99 (Reference 3.8-32) instead of the requirements of Section 11.6 of ACI 349 (Reference 3.8-8), as recommended by RG 1.142 (Reference 3.8-19)."

The above statement is confusing. DCD Reference 3.8-8 is ACI 349-01. The torsion requirements in Section 11.6 of ACI 349-01 are the same as those in Section 11.6 of ACI 318-99. The guidelines provided in RG 1.142 for torsion are meant for ACI 349-97 (not ACI 349-01) and ACI 318- 99. The design provisions for torsion were completely revised from ACI 349-97 to ACI 349-01.

Since the requirements for torsion in ACI 318-99 and ACI 349-01 are identical, the 4th paragraph in Subsection 3.8.4.4.3 quoted above does not appear to be needed. Explain the purpose of this paragraph.

03.08.04-29

3.8.4-29

In DCD Tier 2, Subsection 3.8.4.4.3, "Other Seismic Category I Structures", eighth paragraph, page 3.8-61, the applicant states, "The design and analysis procedures for seismic category I distribution systems, such as HVAC ducts, conduits, and cable trays including their respective seismic category I supports, are in accordance with AISC N690 (Reference 3.8-8) and AISI Specification for Design of Cold-Formed Steel Members (Reference 3.8-34). The following appendices provide additional discussion of the design and analysis of these subsystems.

- Appendix 3A Heating, Ventilation, and Air Conditioning Ducts and Duct Supports
- Appendix 3F Design of Conduits and Conduit Supports
- Appendix 3G Seismic Qualification of Cable Trays and Supports"

Some of the information in Appendix 3A is very general in nature.

The applicant is requested to provide more detailed information and answers to specific questions as follows:

1. The code, AMSE/ANSI G-1-2003, "Code on Nuclear Air and Gas Treatment", provides minimum requirements for the performance, design, construction, acceptance testing, and quality assurance of equipment used as components in nuclear safety-related air and gas treatment systems in nuclear facilities. DCD Tier 2, Appendix 3A does not include this code in its list of codes and standards. Explain why ASME/ANSI is not used in the design of HVAC ducts and supports for the US-APWR plant.

2. In DCD Tier 2, Appendix 3A, "Heating, Ventilating, and Air Conditioning Ducts and Duct Supports", Subsection 3A.1, p. 3A-1, the applicant states that one of the actions taken in designing the HVAC ductwork and supports is to: "Qualify local stresses in ductwork at un-reinforced and reinforced openings". Describe what method(s) are used to accomplish these qualifying actions.

3. In DCD Tier 2, Appendix 3A, Subsection 3A.1.1, “Seismic Category I Ductwork”, the applicant, in addressing the stress criteria used in the selection of duct member sizes and span lengths, states, “Typically stress criteria for ductwork and supports results in selection of standard member sizes and maximum span lengths. However, some HVAC systems require a high degree of leak tightness, experience excessive pressures, or need to account for other external influences (such as tornados) that can require thicker members or closer support spacing.” Describe what HVAC subsystems are included in this apparently more restrictive group (i.e., higher degree of leak tightness, etc.). Also, describe what stress criteria govern the design of these affected HVAC subsystems.

4. In DCD Tier 2, Appendix 3A, Subsection 3A.3, “Loads and Load Combinations”, the applicant presents a general description of the loads and load combinations used in the design of the HVAC ductwork. Also, reference is made in 3A.3 of Appendix 3A to the use of DCD Table 3.8.4-4 for the load combinations used. Table 3.8.4-4 list several load combinations and associated allowable stress coefficients. Provide the specific loads and load combinations used in the HVAC ductwork and associated supports design, and confirm whether the values of the stress coefficients in Table 3.8.4-4 apply to the HVAC ductwork and supports. In addition, DCD Subsection 3.8.4.5 does not mention AISI. The DCD Table 3.8.4-4 mentioned in Subsection 3.8.4.5 for the load combinations and allowable stresses is based on AISC N690. Clarify whether AISI is also applicable to Subsection 3.8.4.5.

5. In DCD Tier 2, Appendix 3A, Subsection 3A.4, the applicant states, “Refer to Section 3.7 for seismic system analysis and qualification requirements of seismic category I and seismic category II SSCs and their supports.” DCD Section 3.7 contains many detailed requirements for seismic design. Provide the specific subsection of DCD 3.7 that is used for the design and analyses procedures. In addition, the DCD presents two approaches for the design and analysis procedures: (1) Simplified Design Approach; and (2) Detailed Design Approach. Describe which HVAC subsystems are designed by either of these two approaches. In addition, clarify the first sentence in 3A.4.2, “For certain geometric and stiffness conditions, the seismic forces are more accurately analyzed for a duct subsystem, including supports.” What are the “geometric and stiffness conditions”?

6. Appendix 3A, Subsection 3A.4.1 (Page 3A-3), “Simplified Design Approach” states, “A simplified analysis is applicable when the seismic accelerations are taken as 1.5 times peak of the support attachment spectrum and the system is isolated from any rod hung seismic category II duct.” Provide the following information:

   Is “Simplified Design Approach” the same as “Equivalent Static Analysis”? If not, provide technical information for this approach. How is it performed? If yes, in SRP 3.9.2 Revision 3, March 2007, “Dynamic Testing and Analysis of Systems, Structures, and Components”, the SRP Acceptance Criteria 2.A.(ii) states that, “An equivalent static load method is acceptable if:

   a. There is a justification that the system can be realistically represented by a simple model and the method produces conservative results in responses.

b. The design and simplified analysis account for the relative motion between all points of supports.
c. To obtain an equivalent static load of equipment or components which can be represented by a simple model, a factor of 1.5 is applied to the peak acceleration of the applicable floor response spectrum. A factor of less than 1.5 may be used with adequate justification."

Provide detailed technical information to demonstrate that US-APWR design meets these criteria.

7. Appendix 3A, Subsection 3A.4.2 (Page 3A-3), "Detailed Design Approach" states that, "For certain geometric and stiffness conditions, the seismic forces are more accurately analyzed for a duct subsystem, including supports. This approach is considered when (a) the duct run is 3-dimensional, (b) the duct run contains a wye fitting, (c) the duct run contains a branch tee fitting with dimensions within 6 inches of the main duct, (d) the duct run is not isolated from a rod hung category II duct, or (e) the duct and/or supports cannot be qualified using standard designs.

   The detailed design approach utilizes an analytical model consisting of a duct run with multiple support points that also account for axial and lateral bracing. The subsystem is analyzed using the response spectrum analysis method for applicable operating and seismic loads, including any accessories and eccentricities that are present."

   Provide the following information:

   a. Explain what are the "standard designs" mentioned in the condition (e) of the first paragraph of the above quote.
   b. Describe the "analytical model" mentioned in the first sentence of the second paragraph of the above quote.
   c. Describe how the response spectrum analysis is carried out. How are the relative displacements at the support points considered?

8. Appendix 3A, Subsection 3A.1.2 (Page 3A-2), "Seismic Category II Ductwork", states that, "…structural steel in-plane stress limits are permitted to reach 1.0 F_y."

   Provide the references for Codes, Standards and Specifications or the technical basis that permit structural steel in-plane stress to reach 1.0 F_y.

9. Appendix 3A, Subsection 3A.3.1 (Page 3A-2), "Loads", states that, "Supports are designed for dead, seismic, thermal loads, and airflow forces at duct elbows, as applicable. Ducts are also designed for the operational and accident pressure loads. Construction live load is considered, however, it is not present during design seismic events."

   Provide the following information:

   The values of construction live load, thermal loads, operational and accident pressure loads, and airflow forces at duct elbows considered. Also, are the overpressure transit loads due to rapid damper closure considered?

10. Appendix 3A, Subsection 3A.4.3 (Page 3A-3), “Axial Brace Spacing” states, “As a general rule, axial braces are spaced at intervals less than 50 feet for straight horizontal runs and less than 25 feet for straight vertical runs.” Provide a reference for this “general rule”.

11. Appendix 3A, Subsection 3A.6.5 (Page 3A-5), “Anchor Bolts”, states “The flexibility of base plates is considered in determining the anchor bolt loads when expansion anchors are used for supports.”
    Provide the following information:
    a. Explain how the flexibility of base plates affects the anchor bolt loads?
    b. Explain how the anchor bolt loads are determined when cast-in-place anchor bolts are used for support. Is the base plate considered to be rigid?

03.08.04-30

3.8.4-30

In DCD Tier 2, Subsection 3.8.4.4.3, “Other Seismic Category I Structures”, eighth paragraph, page 3.8-61, the applicant states, “The design and analysis procedures for seismic category I distribution systems, such as HVAC ducts, conduits, and cable trays including their respective seismic category I supports, are in accordance with AISC N690 (Reference 3.8-8) and AISI Specification for Design of Cold-Formed Steel Members (Reference 3.8-34). Refer to the following appendices for additional discussion of the design and analysis of these subsystems.

- Appendix 3A Heating, Ventilation, and Air Conditioning Ducts and Duct Supports
- Appendix 3F Design of Conduits and Conduit Supports
- Appendix 3G Seismic Qualification of Cable Trays and Supports”

Some of the information in Appendix 3F is very general in nature.

The applicant is requested to provide more detailed information and answers to specific questions as follows:

1. In Appendix 3F, Section 3F.1 (Page 3F-1), “Description”, it states, “Limit spacing of conduit supports to maintain conduit stresses within allowable stresses corresponding to the applicable load combinations.” What is the maximum spacing limitation used for conduit supports? Provide the technical rationale for that value.

2. In Appendix 3F, Subsection 3F.1.2 (Page 3F-1), “Seismic Category II Conduit Systems”, it states, “…structural steel in-plane stress limits are permitted to reach 1.0 F_y.”
   Provide the references for Codes, Standards and Specifications or the technical basis that permit structural steel in-plane stress to reach 1.0 F_y. Is there an exception for cold formed steel?

3. Appendix 3F, Subsection 3F.3.1 (Page 3F-2), "Loads", states, "Conduit systems are designed for dead, live, and thermal loads, as applicable. Design dead load includes the working load (weight) of cables permitted in the conduit. In addition, any accessory loads to the conduit and conduit supports are included in the qualification of the conduit and conduit supports." Provide the following information:
    a. The values of live load and thermal loads considered.
    b. Is there any construction live load?
    c. Why is seismic load not included?
    d. Specify the accessory loads included in the qualification of conduit and conduit supports.

4. Appendix 3F, Subsection 3F.3.2 (Page 3F-2), "Load Combinations", states, "Refer to Subsection 3.8.4.3 for various load combinations applicable to seismic category I SSCs.", and DCD Subsection 3.8.4.3.9 states, "Steel structures are designed using the allowable strength design method in accordance with AISC N690 (Reference 3.8-9) for the load combinations and allowable strength factors provided in Table 3.8.4-4." The load combinations presented in Tables 3.8.4-4 are those of AISC N690. Are the load combinations specified in AISI the same as those of AISC N690?

5. Appendix 3F, Subsection 3F.4 (Page 3F-2), "Design and Analysis Procedures" states, "Refer to Section 3.7 for seismic system analysis and qualification requirements of seismic category I and II SSCs and their supports." Provide the following information.
    a. Provide the exact subsection numbers where the information is presented.
    b. Table 3.7.3-1(a) and Table 3.7.3-1(b) (Pages 3.7-73 and -74) presented damping values for conduits and related supports for SSE and OBE, respectively. What is the conduit fill ratio assumed in the seismic analysis? Per ASCE 4-98, Section 3.5.5.2. (d), the damping values for conduit systems depend on the fill ratio.

6. Appendix 3F, Subsection 3F.4.1 (Page 3F-3), "Equivalent Static Analysis" states, "Equivalent static analysis determined seismic loads for conduit and conduit support systems as detailed 3.7.2.1. The masses considered included nominal size weights, concentrated weights, support members, cable, insulation, conduit (including cantilevers), flexible conduit, and other applicable components." Provide the following information:
    a. Explain what is "nominal size weights" and "flexible conduit". What is the difference between "conduit" and "flexible conduit" mentioned in the above quoted paragraph?
    b. In SRP 3.9.2, Revision 3, March 2007, "Dynamic Testing and Analysis of Systems, Structures, and Components", the SRP Acceptance Criteria 2.A.(ii) states, "An equivalent static load method is acceptable if:
        (1) There is a justification that the system can be realistically represented by a simple model and the method produces conservative results in responses.

(2) The design and simplified analysis account for the relative motion between all points of supports.

(3) To obtain an equivalent static load of equipment or components which can be represented by a simple model, a factor of 1.5 is applied to the peak acceleration of the applicable floor response spectrum. A factor of less than 1.5 may be used with adequate justification."

Provide detailed technical information to demonstrate that US-APWR design meets these criteria above

7. Appendix 3F, Subsection 3F.4.2 (Page 3F-3), "Response Spectrum Modal Analysis", states, "For more exact results, conduit systems can be analyzed using the envelope broadened response spectra methods, considering uniform support motion, or the independent support motion method." Provide information for the following:

   The first approach mentioned in the above quote, the envelope broadened response spectra method, is referred to as the Uniform Support Motion (USM) method in SRP 3.7.3 Revision 3, March 2007, "Seismic Subsystem Analysis". It is required by SRP 3.7.3 that when USM is used, the relative displacements at the support points should be considered in addition to the USM calculation. The second approach mentioned in the above quote is the independent support motion (ISM) method. SRP 3.7.3 specifies that if the ISM method is utilized, all of the criteria presented in NUREG-1061 related to the ISM method must be followed. The applicant is requested to provide technical information in the analysis that the SRP 3.7.3 requirements are met.

8. Appendix 3F, Subsection 3F.5.1 (Page 3F-3), "Allowable Stresses", states, "Allowable stress coefficients are applied in accordance with basic allowables of AISC or AISI. Refer to Subsection 3.8.4.5 for the combination of appropriate allowable stresses with the appropriate load combinations and material specifications."

   DCD Subsection 3.8.4.5 does not mention AISI. The DCD Table 3.8.4-4 mentioned in Subsection 3.8.4.5 for the load combinations and allowable stresses is based on AISC N690. Clarify whether AISI is also applicable to Subsection 3.8.4.5.

9. Appendix 3F, Subsection 3F.5.1.2 (Page 3F-3), "Conduit Supports", states, "Seismic category I and seismic category II supports are designed to withstand the combined effects of normal operating loads (dead weight) acting simultaneously with the seismic loadings."

   The applicant is requested to explain why the live loads and thermal loads are not included in the load combinations.

10. Appendix 3F, Subsection 3F.6.6 (Page 3F-4), "Anchor Bolts", states, "Anchor bolts used for conduit supports, seismic category I and II, are expansion anchors qualified in accordance with ACI 355.2 (Reference 3F-9). The flexibility of base plates was considered in determining the anchor bolt loads."

Are any cast-in-place anchor bolts used? If not, explain why not? Explain how the flexibility of base plates is considered in determining the anchor bolt loads.

03.08.04-31

3.8.4-31

In DCD Tier 2, Subsection 3.8.4.4.3, eighth paragraph, “Other Seismic Category I Structures”, the applicant states, “The design and analysis procedures for seismic category I distribution systems, such as HVAC ducts, conduits, and cable trays including their respective seismic category I supports, are in accordance with AISC N690 (Reference 3.8-8) and AISI Specification for Design of Cold-Formed Steel Members (Reference 3.8-34). The following appendices provide additional discussion of the design and analysis of these subsystems.

- Appendix 3A Heating, Ventilation, and Air Conditioning Ducts and Duct Supports
- Appendix 3F Design of Conduits and Conduit Supports
- Appendix 3G Seismic Qualification of Cable Trays and Supports”

Some of the information in Appendix in 3G is very general in nature.

The applicant is requested to provide more detailed information and answers to specific questions as requested in the following:

1. In Appendix 3G, Section 3G.1 (Page 3G-1), “Description”, it states, “Limit spacing of tray supports to maintain tray stresses within allowable stresses corresponding to the applicable load combination.”

   Provide the maximum spacing limitation used for tray supports, and the technical rationale for that value.

2. In Appendix 3G, Subsection 3G.1.2 (Page 3G-1), “Seismic Category II Cable Tray Systems”, the last sentence states, “….structural steel in-plane stress limits are permitted to reach 1.0 F_y.” Provide the references for Codes, Standards, and Specifications or other technical basis that permit structural steel in-plane stresses to reach 1.0 F_y.

3. Appendix 3G, Section 3G.2 (Page 3G-2), “Applicable Codes, Standards and Specifications”, lists the National Electric Manufacturers Association (NEMA) Standards VE-1 and VE-2, National Electric Code Article 392, 2002, AISI Specification for the Design of Cold-Formed Steel Members, and AISC N690. The applicant is requested to include the following code, specified in SRP 3.7.3,”Seismic Subsystem Analysis”:

   Institute of Electrical and Electronic Engineers (IEEE), Standard 344-1987, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generation Stations.

4. In Appendix 3G, Subsection 3G.3.1 (Page 3G-2), "Loads", it states, "Cable tray systems are designed for dead, live, seismic, and thermal loads, as applicable. Design dead load includes the working load (weight) of cables permitted in the tray (also known as "raceway"). Construction live load is considered in addition to the maximum weight of cables and trays." DCD Subsection 3.8.4.3.4.6,"Construction Loads", does not provide this information. The applicant is requested to provide information for the values of live load, thermal load, and Construction Live Load considered in Appendix 3G.

5. Appendix 3G, Subsection 3G.3.2 (Page 3G-2), "Load Combinations", refers to DCD Subsection 3.8.4.3 for the information, and DCD Subsection 3.8.4.3.9 states, "Steel structures are designed using the allowable strength design method in accordance with AISC N690 (Reference 3.8-9) for the load combinations and allowable strength factors provided in Table 3.8.4-4." The load combinations presented in Tables 3.8.4-4 are those of AISC N690. Are the load combinations specified in AISI the same as those of AISC N690? The applicant is requested to include AISI in the description of Subsection 3.8.4.3.

6. Appendix 3G, Subsection 3G.4 (Page 3G-2), "Design and Analysis Procedures" states, "Refer to Section 3.7 for seismic system analysis and qualification requirements of seismic category I and II SSCs and their supports." Provide the following information.
   a. Provide the exact subsection numbers where the information is presented.
   b. Table 3.7.3-1(a) and Table 3.7.3-1(b) (Pages 3.7-73 and -74) presented damping values for full cable trays and empty cable trays for SSE and OBE, respectively. What is the cable fill ratio assumed in the seismic analysis?
   c. Per ASCE 4-98, Section 3.5.5.2, the damping values for cable trays depend on the input acceleration level, cable fill ratio, and the ability of the cables to move within the trays during the seismic event. In US-APWR design, are cables restrained by spray-on fire protection materials? Is it a welded steel cable tray system or a bolted steel cable tray system?

7. Appendix 3G, Subsection 3G.4.1 (Page 3G-2), "Equivalent Static Analysis" states, "Using equivalent horizontal and vertical static forces applied at the center of gravity of the various masses, the cable tray system is conservatively modeled to develop standard tray spans and support designs. The seismic accelerations are taken as 1.5 times peak of the support attachment spectrum during this analysis except when technical justification is provided for a lower factor unique to certain configuration." Provide the following information:
   a. Technical information for how the cable tray system is modeled to develop standard tray spans and support designs.
   b. In SRP 3.9.2 Revision 3, 2007,"Dynamic Testing and Analysis of Systems, Structures, and Components", the SRP Acceptance Criteria 2.A.(ii) states that, "An equivalent static load method is acceptable if:
      (1) There is a justification that the system can be realistically represented by a simple model and the method produces conservative results in responses.

(2) The design and simplified analysis account for the relative motion between all points of supports.
(3) To obtain an equivalent static load of equipment or components which can be represented by a simple model, a factor of 1.5 is applied to the peak acceleration of the applicable floor response spectrum. A factor of less than 1.5 may be used with adequate justification."

The DCD meets criterion (3) above only. The DCD also needs to meet criteria (1) and (2).

8. Appendix 3G, Subsection 3G.4.2 (Page 3G-3), "Modal Response Spectrum Analysis", states, "For more exact results, cable tray systems can be analyzed using the envelope broadened response spectra methods, considering uniform support motion, or the independent support motion method."
The first approach mentioned in the above quote, the envelope broadened response spectra method, is referred to as the Uniform Support Motion (USM) method in SRP 3.7.3 Revision 3, 2007,"Seismic Subsystem Analysis". SRP 3.7.3 states that when USM is used, that the relative displacements at the support points should be considered in addition to the USM calculation. The second approach mentioned in the above quote is the independent support motion (ISM) method. SRP 3.7.3 specifies that if the ISM method is utilized, all of the criteria presented in NUREG-1061 related to the ISM method must be followed. The applicant is requested to state whether the analyses performed meet the guidance in SRP 3.7.3, regardless of which of the two methods are used, USM or ISM.

9. Appendix 3G, Subsection 3G.5.1 (Page 3G-3), "Allowable Stresses", states, "Allowable stress coefficients are applied in accordance with basic allowable of AISC or AISI. Refer to Subsection 3.8.4.5 for the combination of appropriate allowable stresses with the appropriate load combinations and material specifications."
DCD Subsection 3.8.4.5 does not mention AISI. The DCD Table 3.8.4-4 mentioned in Subsection 3.8.4.5 for the load combinations and allowable stresses is based on AISC N690. Clarify whether AISI is also applicable to Subsection 3.8.4.5.