RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

08/01/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1040-7139 REVISION 3**
SRP SECTION:	**03.08.01 – Concrete Containment**
APPLICATION SECTION:	**3.8.1**
DATE OF RAI ISSUE:	**07/01/2013**

QUESTION NO. 03.08.01-18:

On April 3, 2013, the applicant submitted a markup of DCD Tier 2 Section 3.8 to provide updated information related to a seismic design change.

In Subsection 3.8.1.4.1.1, "Analytical Methods," the fourth paragraph (Page 3.8-10) states, "The design forces due to the seismic load obtained by the square root of sum of the squares (SRSS) method are beyond those obtained from inelastic analysis, at the PCCV [prestressed concrete containment vessel] shell/mat interface. The associated redistribution effects are found to be insignificant."

The applicant did not describe, or provide reference sections in the DCD related to the terms "inelastic analysis," and "associated redistribution effects," which are referred in the above sentence. The applicant is requested to describe and/or provide referenced DCD sections for the terms listed above.

ANSWER:

The term "associated redistribution effects" refers to the redistribution of internal forces and moments due to concrete cracking, which can affect the stiffness of the prestressed concrete containment vessel (PCCV) and cause shifting of the neutral axis. This redistribution has been taken into account using an iterative process and is discussed in Section 3.8.1.4.2.1 of the Design Control Document (DCD).

The term "inelastic analysis" will be removed from the DCD. See Attachment 1.

Impact on DCD

Section 3.8.1.4.1.1 of the DCD will be revised as shown in Attachment 1.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on the Technical/Topical Report.

This completes MHI's response to the NRC's question.

between elements are accounted for in the models. The FEs used have membrane, bending, and tangential and radial shear capability.

Computer code development, verification, validation, configuration control, and error reporting and resolution are in accordance with the Quality Assurance requirements of Chapter 17.

3.8.1.4.1 Analyses for Design Conditions

3.8.1.4.1.1 Analytical Methods

The PCCV structure is analyzed by the use of the linear elastic FE computer program ANSYS (Reference 3.8-14). The PCCV is isolated from other structures for the analysis of shell and domes stresses, however, it is supported on and anchored to a common basemat with those structures. The PCCV structure is idealized for analysis and modeled with ANSYS as a structure consisting of isoparametric membrane-bending plate elements. MIC-03-03-00057

The three-dimensional global FE analysis model as represented in Figures 3.8.5-75, through 3.8.5-810, and 3.8.5-9 includes the overall PCCV structure, as well as the R/B, theeast PS/B, west PS/B, A/B containment internal structure and the common basemat to which all these structures are supported. The FEs used for the PCCV analyses (Figure 3.7.2-1) have membrane, bending, tangential, and radial shear capability. The model accounts for effective prestress equivalent to the variation of tendon friction due to losses or changing geometry, for example the inverted U-shape tendons' transition from cylinder to dome. In developing the model, the mesh size is chosen to comply with the following basic considerations and empirical checks. MIC-03-03-00057 MIC-03-03-00060

- When considering areas, such as the main steam penetration, concentrated load, or reaction areas, the critical location for shear is generally one-half the thickness away from the opening edge and, the element size should account for this fact.
- The mesh discretization is chosen to assure adequate representation of the controlling stresses for key elements of the design such as for the general shell, the basemat, the discontinuities at cylinder base and the intersection with the dome, the large openings, buttresses, high energy piping penetrations, and pipe whip restraint locations, where required.

The behavior of the PCCV model overall is typically axisymmetric, particularly under dead and pressure loads. The non-axisymmetric effects of such loads including but not limited to severe wind, tornadoes, hurricane, earthquake, and pipe rupture are taken into account in the FE analysis as required by SRP 3.8.1, Section II.4.B (Reference 3.8-7). DCD_02-03 S02 DCD_02-03 S01

In designing the PCCV superstructure, the square root of the sum of the squares (SRSS) method based on elastic analyses is used to evaluate the seismic load for the three components of the earthquake. The design forces due to the seismic load obtained by the SRSS method are beyond those obtained from inelastic analysis, at the PCCV shell/mat interface. The associated redistribution effects are found to be insignificant.greater than the design forces due to redistribution effects from concrete cracking at the PCCV DCD_03.08.01-18 shell/mat interface. Concrete cracking considerations, including the redistribution of section forces and moments, is discussed further in Subsection 3.8.1.4.2.1. DCD_03.08.01-18

Stress analyses of the FE models are performed considering the following loads defined in accordance with ASME Code, Section III, Article CC-3000 (Reference 3.8-2):

- Dead load
- Live load (including polar crane loads as applicable)
- Prestressing load
- Internal pressure
- Seismic load
- Wind load
- Thermal load

With regard to thermal load, in order to consider thermal effects in the global FE model due to expansion of the liner, the liner plate loading is taken into account without explicitly modeling the stiffness of the liner.

Prestressing force is calculated considering the losses due to slip at anchorage, elastic shortening, creep of concrete, shrinkage of concrete, stress relaxation and tendon friction.

Large openings are modeled in the three-dimensional global FE analysis model described above. The design of the large openings for the one equipment hatch and the two personnel airlocks use the results of FE analyses using this global FE model. In accordance with ASME Code, Section III, Subarticle CC-3544 “Curved Tendons” and Subarticle CC-3340(a), the global model accounts for all forces imposed by tendons curved around the opening, such as effective prestress equivalent to the variation of prestress forces due to friction and other loses. The global FE model has membrane, bending and tangential, and peripheral and radial shear capability.

The PCCV buttresses are modeled in the three-dimensional global FE analysis model described above so that the discontinuity effects of the normal shell and the thickened buttress can be evaluated in the design. Local effects are also considered using the test results documented in Testing of Large Prestressing Tendon End Anchor Anchorage Regions, by T.E. Johnson (Reference 3.8-15).

Seismic Analysis of the PCCV for Structural Design MIC-03-03-00060

Response spectrum analysis with the Lindley-Yow Method, described in NRC Regulatory Guide 1.92 (Reference 3.8-75), is selected for the seismic analysis of the PCCV. The Lindley-Yow method divides the total seismic response into two components: periodic response with the ground motion (“out-of-phase” response) and rigid response with the ground motion (“in-phase” response). Response spectrum analysis is performed for the