RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/08/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 490-3732 REVISION 0**
SRP SECTION:	**03.08.01 – Concrete Containment**
APPLICATION SECTION:	**3.8.1**
DATE OF RAI ISSUE:	**11/23/2009**

QUESTION NO. 03.08.01-10:

In its response to Question 3.8.1-10, MHI states that considerations of concrete cracking effects on the global model of the PCCV are discussed in their response to Question 3.8.1-(0)8. It is further stated that the presence and the extent of the cracking within a section, and the distribution of forces and moments within a cracked section, is determined and evaluated as part of the post-processing of the global FE model results.

The staff finds that MHI's response to this question is not acceptable. MHI's response to this question is based on the response to Question 3.8.1-8 in which MHI states that the concrete will not crack. This implies that the redistribution of section forces and moments due to concrete cracking was not included in the analysis. However, the implication in the above response to this Question 3.8.1-10 seems to be that there is cracking and that cracking is determined in the post-processing of the global FE model results. The applicant is requested to explain whether or not concrete cracking was considered in the PCCV analysis. If it was considered, how was it accounted for in the analysis, and how were the forces and moments redistributed?

ANSWER:

This response replaces the previous response submitted via MHI letter UAP-HF-10033, dated February 4, 2010 (ML100430768).

The consideration of the effects of cracked concrete is addressed in both the dynamic analysis and the static analysis/design as follows:

Dynamic Analysis:

Technical Report MUAP-10006, Rev. 3, Section 02.3.3,02.4.2, and Appendix 2-A, provide an explanation of the methodology and stiffness reduction used in the prestressed concrete containment vessel (PCCV) Dynamic Analysis to account for concrete cracking due to dynamically apply loads. The Reactor Building (R/B) complex soil-structure interaction (SSI) analysis considers PCCV stiffness reduction due to concrete cracking. Technical Report MUAP-10006, Rev. 3, and DCD Subsection 3.7.1.2 Rev. 3 describe the PCCV dynamic

three-dimensional finite element (FE) modeling approach. This includes details of how two levels of stiffness and damping were utilized.

The following are the two analyses performed for the Dynamic FE Models:

1. A full stiffness dynamic model representing an uncracked concrete structural behavior;

2. A reduced stiffness dynamic model representing a cracked concrete structural behavior.

Two sets of response spectra are created, one representing cracked concrete and one representing an uncracked concrete. The resultant data sets create an envelope of bounding responses that are used in structural design of PCCV concrete sections. Details of the reduced stiffness selection values can be found in the Technical Report MUAP-10006, Rev. 3, Appendix 2-A.

Static Analysis and Design:

A static structural model is prepared for design using the results from the dynamic model as inputs. The static analysis is performed on an uncracked condition using the controlling structural response (cracked and uncracked) from the dynamic analyses. Use of an uncracked concrete for static analysis yields conservative results in terms of the magnitude of forces and moments. Concrete cracking is considered in the design, after the static analysis of the PCCV is performed. Concrete cracking is considered for both mechanical and thermal loading conditions.

From the static analysis, tensile zones within the concrete section are identified. A crack is postulated in this tensile area and the resulting neutral axis of the uncracked section is shifted accordingly. Forces and moments are recalculated for the section relative to the new neutral axis and tensile zones are re-evaluated. This analytical process is iterated until a balance of forces is obtained within the cracked section. These iterative analyses allow evaluation of the transformed section and an assessment of cracking depth.

PCCV design analysis redistributes forces and moments, including those resulting from the loads described by ASME Section III, Division 2, Table CC-3230-1, Abnormal/Extreme Environmental equation. Loads described by the Abnormal/Extreme Environmental case are considered to occur concurrently without time sequencing. This methodology also considers concrete cracking effects for both primary loads (including seismic safe-shutdown earthquake (SSE) without thermal) and primary plus secondary (including seismic SSE and thermal) loads. The highest resulting demand to capacity ratio is determined.

US-APWR Design Control Document (DCD) Rev. 3, Subsection 3.8.1.4.2.1 provides additional discussion of PCCV cracking.

Impact on DCD

There is no impact on the DCD.

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.