RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

05/31/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 985-6948 REVISION 3**
SRP SECTION:	**03.08.03 – Concrete and Steel Internal Structures of Steel or Concrete Containments**
APPLICATION SECTION:	**3.8.3**
DATE OF RAI ISSUE:	**01/08/2013**

QUESTION NO. 03.08.03-109:

The staff reviewed the applicant's response to RAI 905-6311, Question 03.08.03-80 regarding the calculation methods and the test results of the 10th scale test. Regarding Item 4, the RAI response explained that the strength of the pressurizer chamber wall was overestimated by calculation, because the calculation was based on its shear strength alone, and did not consider the flexural-shear interaction behavior due to slenderness of the wall. To ensure that this overestimation of strength in the design of the US-APWR containment internal structure (CIS) steel-concrete (SC) walls does not occur, the staff requests that the applicant explain whether and how the flexural and shear interaction is considered in the US-APWR CIS SC wall design.

ANSWER:

Flexure and shear interaction is considered directly in the US-APWR steel-concrete (SC) wall design approach. This is done in accordance with Technical Report MUAP-11019, Rev. 1, Section 8 - Design of SC walls for Combined Forces.

- Section 8.1 of Technical Report MUAP-11019, Rev. 1 presents the design approach for combined out-of-plane shear demands.
- Section 8.2 of Technical Report MUAP-11019, Rev. 1 discusses the calculation of the balance point on the axial load-bending moment (P-M) interaction curve.
- Section 8.3 discusses the Tresca yield surface that is used for the steel faceplates of the SC walls.
- Section 8.4 presents the design approach for combined axial tension, flexure, and in-plane shear.
- Section 8.5 presents the design approach for combined axial compression (less than the balance load), flexure, and in-plane shear.

- Section 8.6 presents the design approach for combined high axial compression (greater than the balance load), flexure, and in-plane shear.

- Section 8.7 discusses the limits imposed on the demand-to-capacity ratios to include an additional level of conservatism and account for secondary effects.

The overestimation of the strength of the pressurizer chamber wall referenced in the response to RAI 905-6311, Question 03.08.03-80 is unrelated to the US-APWR SC wall design criteria and approach. That overestimation was reported in Technical Report MUAP-10002, Rev. 0 as part of the simplistic analysis and evaluation of the 1/10th scale model of the containment internal structure (CIS) which was tested by MHI in Japan. This evaluation could not account for the flexure-shear interaction effects because: (i) the entire pressurizer was treated as one structural element (i.e., wall), and (ii) no rules for flexure-shear interaction effects on the strength of a structural element were developed or are available.

In contrast, as explained in Technical Report MUAP-11019, Rev. 1 Section 8, the US-APWR design approach consists of modeling each structural element (e.g., wall or slab etc.) with several finite elements. The design demands for each finite element are calculated by performing analysis in accordance with Technical Report MUAP-11018, Rev. 1. The results from the analyses include eight design demands consisting of three membrane forces, three moments, and two out-of-plane forces for each finite element of the model.

The US-APWR SC wall design procedure consists of confirming that for each finite element of the model:

(i) The individual design demands are less than or equal to the corresponding individual design capacities calculated using applicable design strength equations from Sections 3 - 7 of Technical Report MUAP-11019, Rev. 1, and

(ii) The area of steel required for the combinations of the various demands is also less than the total area of steel available from the tie bars and steel faceplates of the SC wall using applicable design strength equations from Section 8 of Technical Report MUAP-11019, Rev. 1.

Thus, the effects of flexure-shear interaction are included explicitly in the US-APWR design approach by: (i) conducting three-dimensional (3D) finite element analysis according to Technical Report MUAP-11018, Rev. 1, and (ii) performing SC wall design according to the criteria in Technical Report MUAP-11019, Rev. 1, particularly Sections 8.4 - 8.6.

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.