RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/27/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1066-7306 REVISION 4**
SRP SECTION:	**03.08.01 – Concrete Containment**
APPLICATION SECTION:	**3.8.1**
DATE OF RAI ISSUE:	**12/12/2013**

QUESTION NO. 03.08.01-24:

During the November 4-8, 2013 structural audit, the staff reviewed the applicant's calculation, PCV-13-05-230-009, Revision 0, "Post-Tensioned Concrete Containment Vessel Post-Processor Theory," which describes the methodology and theory being used by the applicant for implementing the requirements of the ASME Code in the design of the pre-stressed concrete containment vessel (PCCV) as well as the Reactor Building (R/B) Complex basemat. Based on this review and discussions with the applicant, the staff understands that the applicant is assuming the straight line theory of stress and strain to be applicable for factored load design performed in accordance with Article CC-3500, "Containment Design Details" of the ASME Code. The relationship between concrete stress and strain, however, is generally recognized to be non-linear above service loads; a commonly used model being that developed by Hognestad. Based on the assumed straight line relationship, the strain in the concrete corresponding to the maximum allowable primary-plus-secondary membrane and bending compressive stress of 0.85f'c does not correspond to a limiting strain of 0.002 in./in. as stated in Note (3) of Table CC-3421-1, "Allowable Compression Stresses for Factored Loads" of the ASME Code. The ASME Code also sets limits on allowable strain in the reinforcement in Article CC-3422, "Reinforcing Steel." One potential implication of the assumed straight line relationship is that the strain in the tension steel may be underestimated after yield. As a result, compliance with the ASME Code reinforcing strain limits may not be accurately predicted.

The staff requests that the applicant provide additional information concerning the appropriateness of assuming a straight line stress-strain relationship for factored load design conducted in accordance with ASME, Section III, Division 2, specifically:

- The accuracy of analytical results produced when concrete compressive stress levels exceed the ASME elastic limit of 0.6f'c.
- Conformance of the assumptions, namely the straight line theory of stress and strain, with the provisions of the ASME Code.
- Any limitations or conditions of use for their post-processor that bounds its applicability, such as stress and strain limits.

ANSWER:

1. The design stresses are based on static equilibrium and strains are not initially used in the calculation of the primary service or factored stresses. After stress determination, strains are subsequently calculated based on strain compatibility. This methodology satisfies the requirements for equilibrium and compatibility of strain described in Subarticle CC-3511.1 of the ASME Section III, Division 2 Code. When considering primary factored loads only, the computed reinforcement strains are less than the code allowable strain corresponding to a stress of 0.9fy. The containment remains within the elastic range for all primary factored loading conditions. Under primary plus secondary loading, an increase in the strain limit is permitted by ASME Section III, Division 2, Subarticle CC-3422.1(d). The methodology used to design the PCCV is in accordance with the design code and the calculated stress output, and accuracy of the DCRs presented for the design of the PCCV, are not affected by the straight-line theory of concrete stress and strain.

2. The methodology satisfies the requirements for equilibrium and compatibility of strain described in Subarticle CC-3511.1 of the ASME Code as described above. The discussion in answer 1 above describes the conformance of the assumptions.

3. The post-processor is bounded by applicability to concrete containment structures in accordance with ASME Section III Division 2, 2001 through 2003 addenda. The post-processor does not apply to prestressed concrete structures with grouted tendons. Evaluations for stress and strain limits are in accordance with CC-3400.

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 Reports.

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