SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/08/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 662-5131 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:	**11/15/2109**

QUESTION NO. 03.08.03-29:

The only change in the text of the Amended Response to Question 03.08.03-07 (dated September 2009) from that given in MHI's initial response is a renumbering of two references cited in Part (d) of the response, from Reference Nos. 6 and 7 to Reference Nos. 1 and 2. The staff reviewed the amended response, including the two technical papers that were translated into English. The staff finds that Parts (b) and (c) of the amended response are acceptable.

For Part (a) of the amended response: As stated in its initial evaluation the staff notices that all of the temperature plots begin with the calculated temperatures one (1) hour after the accident, and in all cases the maximum concrete temperature is shown to be 300F or less. However, it is not obvious that this temperature of 300F will not be exceeded at any time during the first hour following the accident. MHI is requested to show a typical temperature profile through one of the SC module walls for the first 60 minutes following the accident which shows that the temperature of the concrete surface does not, in fact, exceed at any time the 300F maximum shown for one (1) hour after the accident.

For Part (d) of the Amended Response: The staff reviewed the two referenced papers, Ref. 1 and Ref. 2 (in Attachment 1 of the Amended Response), and notices that the tests described in these technical papers appear to cover several conditions of temperature rise and support configurations for equipment supports embedded in the SC module walls. The tests provide support for MHI's claim that "By the experiments of References 1 and 2, it has been confirmed that steel faceplates and studs do not have any damage and the structural integrity of the SC modules is maintained during accidents which raise temperature such as LOCA and pipe rupture".

MHI is requested to provide information that addresses the following:

1. The response states that even for all accident conditions the maximum local concrete temperature does not exceed 300F. As stated above for Part (a), MHI is requested to show that the concrete at its interface with the steel faceplates does not exceed 300F during the first 60 minutes following the accident.

2. What type of welding in used to secure the studs to the steel faceplates in the pullout of support stud tests? Is this the same type of welding that will be used on the US-APWR?

3. How are shear stud diameter, length, and head size determined in the design of the USAPWR SC modules? Describe the tests that show the appropriateness of any formulas used to determine these parameters.

4. Show that the parameters that exist in the actual SC modules (such as actual wall thicknesses, steel plate thickness, stud sizes and spacing, etc.) are properly and adequately bounded by the corresponding parameters of the test specimens. For example, show how these values would appear in the various test result curves presented in these papers.

5. While the tests described in the technical papers show adequate performance for the maximum temperatures selected, it is important to know how significantly higher temperatures would affect the structural integrity of the SC modules. In particular, at what temperature of the concrete surface would significant reductions occur in the strength of the stud anchorages and steel faceplates?

6. How is the steam generated by the high temperature in the concrete accommodated? Are there any vent holes provided in the steel faceplates?

The staff finds that the MHI's amended response does not specifically address the question concerning the possible need to physically assess the condition of the concrete following any accident as required in ACI 349. MHI is requested to confirm whether thermocouples (or other temperature measuring device) will be installed at the interface between the faceplates and the concrete to assure that the calculated temperatures of the concrete are not, exceeded during any accident. In addition, MHI is requested to describe the procedures that will be used to assess the condition of the concrete between the steel faceplates following any accident that results in elevated temperatures.

ANSWER:

The original response to this RAI letter number 662-5131, Question 3.8.3-29 (ML110100361) dated December 28, 2010, remains correct with the following supplemental information regarding updated reference locations, design codes, and thermal conditions. For clarity, the original response is repeated below and the supplemental information follows.

Part 1)

It is acknowledged that the maximum concrete temperature may exceed 300F in local areas. Please refer to the response for RAI 491-3733 Question 03.08.03-20 Part a) for discussion concerning the maximum concrete temperature and its acceptability.

Part 2)

The studs to be used on the US-APWR are to be secured to the steel faceplates by stud arc welding. Stud arc welding is standard practice for the attachment of headed studs.

Part 3)

Shear stud parameters (diameter, length, head size) for the US-APWR will be designed based on the provisions of ACI 349-01, Appendix B. The provisions of ACI-349 are based on extensive testing. Furthermore, the tests performed in Reference 1 and 2 of Response to RAI 322-1999 demonstrate the stud capacity is significantly higher than the allowable design value, even if cracks are generated by heating.

Part 4)

Tables 1 and 2 below summarize relevant SC module parameters for tests from the references provided in the Amended Response to RAI 322-1999 and for representative SC walls of the US-APWR design. Table 1 demonstrates that the tested reinforcement ratios bound the design reinforcement ratios of the US-APWR.

Table 1 Reinforcement Ratio Parameters

Table 2 Stud Parameters

Part 5)

Reference 1 of Response to RAI 322-1999 tests a rise in temperature of 540F (300C). This bounds the maximum temperature rise considered for the US-APWR SC walls which is 475F (580F Refueling Cavity transient temperature – 105F winter normal operation temperature) based on DCD Figure 3.8.1-13 and DCD Table 3.8.1-3. The test results on the heat treated test piece show a 5 to 25% reduction in pull out strength compared to the non-heat-treated sample, but the load bearing ability was still three to four times higher than the allowable design value. The tests also show the ability of the steel plate to resist buckling at a *B*/*t* ratio (stud pitch) of 17.8. Therefore this test demonstrates the adequacy of the stud anchorage for the temperature variation required for the design of the US-APWR.

Part 6)

The steel concrete composite walls are formed by carbon steel faceplates and web plates with a nominal thickness of 0.5 inches. The walls are anchored to reinforced concrete basemats. The carbon steel faceplates do not have vent holes. The SC walls are not sealed at their tops; the SC walls are capped with reinforced concrete slabs which permit steam to escape. The SC faceplates also have holes for inspection during installation of the concrete as described in the response to Amended Response RAI 322-1999 question 3.8.3-10. These holes remain permanently in the steel plates and would permit steam to escape. The response to RAI 491-3733 question 03.08.03-20 provided temperature distribution data which demonstrates that the temperatures across the concrete portions of SC walls increase gradually under accident conditions. For example, Figure 3-2 of the response to question 03.08.03-20 shows that it takes approximately 1 day after a postulated accident for the temperature to reach 212° F at a depth of 10” from each outside face of a 48”-thick secondary shield SC wall. It is also a reasonable assumption for a gap to exist between the concrete and the back of the steel faceplate due to nominal shrinkage of the concrete, and for cracking to occur during accident conditions (see response to questions 03.08.03-26 and 03.08.03-32 in this RAI for further discussion of cracking). Considering the gradual increase in temperatures from the accident, the presence of gaps at the steel/concrete interface and cracks in the SC module concrete, the presence of inspection holes in the faceplates, and the fact that the tops of the SC walls allow the steam to escape from the opening, no specific details for venting are provided in the steel faceplates. It should be noted that the physical configuration of these walls is similar to some biological shield walls used at current US plants.

Further, the steel plates will not reduce the temperatures seen by the concrete in the steel composite walls significantly. As part of the assessment with respect to temperatures, the outside surface of the steel plate exposed to containment ambient temperatures is essentially the same as the concrete surface. Therefore, with respect to temperature effects, thermocouples mounted within containment to measure ambient temperatures serve effectively the same purpose as any thermocouples that would be mounted on the interior surface of the steel faceplates.

Therefore, the thermocouples installed to monitor accident temperatures inside containment which are used to monitor containment temperatures during all plant conditions, will identify any unusual increase in temperature which may increase the temperature of the SC composite walls. The small break LOCA accident temperatures produced in concrete and the containment (worse case scenario as indicated by Chapter 16, B 3.6.6) are well analyzed and the concrete is designed for these conditions with margin. Furthermore, it is assumed that the steel plate surface temperature is the concrete surface temperature. This is due to the heat transfer characteristics of steel and the relative thickness of the steel faceplate. Therefore MHI will not have thermocouples between the steel faceplate and the concrete surface.

The SC modules of the US-APWR may be damaged due to a severe earthquake or high temperatures from an accident. After such an event the condition of the SC modules shall be assessed by visual inspection, nondestructive testing, and analysis as required. If necessary, the SC modules will be repaired prior to restart. In this case, procedures will be developed based on industry best practices, using as guidance relevant procedures described in ASME Chapter XI, Division 1, Subsection IWA and IWE.

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.

SUPPLEMENTAL INFORMATION:

Part 1)

Technical Report MUAP-11018, Rev. 1, Figure 6-1 provides typical temperature profiles through three representative containment internal structure (CIS) steel concrete (SC) walls following an accident.

Part 3), 4) and 5)

To ensure that all reference documents are readily available for reviewers, References 1 and 2 of Response to RAI 322-1999 have been included as References 8 and 9 respectively in Technical Report MUAP-11005, Rev. 1, Appendix E. The comparison of physical test parameters to the US-APWR design parameters provided in Table 1 of part 4) of the original response has been expanded in Appendices A through D of Technical Report MUAP-11005, Rev. 1. These appendices illustrate the correlation of the various test specimens in the experimental database to the design parameters of US-APWR SC walls. Additional physical testing was also performed on full-scale and large-scale specimens representing the actual configuration of the US-APWR SC walls, as summarized in MUAP-11013, Rev. 2, Appendix B. These tests further confirm the appropriateness and conservatism of the applicable American Concrete Institute (ACI) 349-06 code provisions used to design the US-APWR SC walls.

Part 3)

The US-APWR SC wall shear studs are designed based on the provisions of ACI 349-06, Appendix D, rather than ACI 349-01, Appendix B.

Part 5)

The maximum Refueling Cavity transient temperature has been revised from 580°F to 550°F based on revised Design Control Document (DCD) Figure 3.8.1-13. This reduces the maximum temperature rise considered for the US-APWR SC walls from 475°F to 445°F. This temperature rise remains bounded by the temperature rise tested in Reference 8 of Technical Report MUAP-11005, Rev. 1, and the conclusion of the original response remains valid.

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.