SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/27/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 858-6126 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:	**10/25/2011**

QUESTION NO. 03.08.03-47:

Section 2.1 of MHI TR 11013-P (R1) states that "While a 1/6th scale test was also performed to evaluate the thick primary shield walls, further study is required to assess their stiffness and strength." Explain what is meant by this statement, how and when this further study will be done, and how this information will be used in the analysis and design of the CIS. In addition, explain whether shrinkage and creep effects are considered in the design of the primary shield structure and how the large wall thicknesses were determined, i.e., for shielding requirements or for structural strength.

This answer supplements the previous MHI answer that was transmitted on March 29, 2013 by letter UAP-HF-13064 (ML13107B428). The supplemental response presented below was discussed with the Nuclear Regulatory Commission (NRC) staff during the Design Certification Document (DCD) Tier 2, Section 3.8 Audit conducted during the week of November 4, 2013. For clarity, the response is repeated below and the supplemental information regarding design checks for the primary shield structure follows.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-12051 (ML12075A108).

A benchmarking finite element (FE) analysis has been performed for the 1/6th scale test as part of Task 3 (MUAP-11013, Rev. 2, Section 5.0). A summary of this analysis is available in Technical Report MUAP-11013, Rev. 2, Section 8 of Appendix A.

Shrinkage and creep effects have been considered in the design of the primary shield structure. The effects of creep are included in the axial compression design strength as described in Sections 4.1 and 4.2 of Technical Report MUAP-11019, Rev. 1. The effects of

shrinkage are included by eliminating the concrete contribution to the in-plane shear strength and the out-of-plane shear strength.

The primary shield wall thickness is determined from radiological shielding requirements.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Report:

There is no impact on the Technical/Topical Report.

SUPPLEMENTAL INFORMATION:

The design of the primary shield structure will include demand/capacity checks for lateral shear as well as axial force and moment (P-M), as described in the attached revision to Appendix 2 of Technical Report MUAP-11019, Rev. 1.

Impact on DCD

The maximum demand/capacity ratios reported in Table 3L-29 will be expanded based on revised calculations to be performed as discussed.

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 Report:

Appendix 2 of Technical Report MUAP-11109, Rev. 1, will be revised as attached.

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

APPENDIX 2

DESIGN CRITERIA FOR PRIMARY SHIELD STRUCTURE

TABLE OF CONTENTS

1. Structure Geometry A2-2
2. Physical Testing and Benchmarked NIFE Analysis A2-4
3. NIFE Analysis of Actual PSW and Design Lateral Load Capacity Assessment A2-10
4. Additional Design Considerations for Flexural and Axial Loading A2-12

LIST OF FIGURES

Figure A2-1 Geometry and multi-cellular layout of primary shield A2-2

Figure A2-2 Lateral load capacity of the 1/6th scale model of the primary shield A2-5

Figure A2-3 Lateral load capacity of primary shield structure A2-8

Figure A2-4 Primary shield wall segment aspect ratios A2-9

Figure A2-5 Variation of nominal lateral load capacity of primary shield with direction.......... A2-9

Figure A2-6 Comparison of NIFE analysis with nominal lateral load capacity A2-10

Figure A2-7 Comparison of NIFE analysis for operating and accident thermal conditions with nominal lateral load capacity A2-11

1. Structure Geometry

The primary shield is a unique structure consisting of several steel plates arranged to form multi-cellular structures that are filled with concrete. Figure A2-1 shows geometric details of the steel multi-cellular structures at different elevations of the primary shield structure. Figure A2-1(a) shows the overall geometry of the primary shield structure and the thicknesses of the steel plates at different elevations along the structure in height (see also Figure 1.1-1 in this TeR). As shown, the primary shield uses steel plates with thicknesses varying from 0.5 in. to 2.0 in., and three ranges of elevations are considered: (i) between elevations 3’-7” and 15’-10” (referred to as the bottom portion), (ii) between elevations 15’-10” and 35’-11” (middle portion), and (iii) between elevations 35’-11” and 46’-11” (upper portion). The steel multi-cellular structures at these three elevations are shown in Figures A2-1(b), (c), and (d), respectively.

Figure A2-1 Geometry and multi-cellular layout of primary shield

As shown in Figure A2-1(b), the bottom portion of the primary shield from elevations 3'-7" to 15'-10" consists of three steel plates and numerous web plates that are all 0.5 in. thick. This portion of the structure is encased in massive concrete (category 5 structure) becoming part of the foundation for the rest of the structure.

As shown in Figure A2-1(c), the middle portion of the primary shield from elevations 15'-10" to 35'-11" consists of three steel plates and numerous web plates that are primarily 0.625 in. thick. The top of the middle portion is covered by a 2.0 in. thick plate, which separates it from the top portion of the primary shield. The middle portion is a significant multi-cellular structure with circular inner diameter and polygonal outside dimensions. As shown in Figure A2-1(d), the top portion of the primary shield from elevations 35'-11" to 46'-11" consists of two steel plates and numerous web plates that are primarily 0.5 in. thick. This is also a significant multi-cellular structure with polygonal dimensions.

2. Physical Testing and Benchmarked NIFE Analysis

APPENDIX 2 REFERENCES:

1. American Concrete Institute, "Code Requirements for Nuclear Safety Related Concrete Structures," ACI 349-06, November 2006.

2. Mitsubishi Heavy Industries, Ltd., "Research Achievements of SC Structure and Strength Evaluation of US-APWR SC Structure Based on 1/10th Scale Test Results," MUAP-11005, Revision 1, December 2012.

3. Mitsubishi Heavy Industries, Ltd., "Containment Internal Structure Design and Validation Methodology," MUAP-11013, Revision 2, February 2013.

4. URS Corporation, "1/6th Scale Test of Primary Shield Structure: Analysis Beyond SSE Level Loading," Calculation Report CIS-13-05-150-003, Revision 1, October 2013.