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TOKYO, JAPAN

March 5, 2009

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09073

Subject: **MHI's Responses to US-APWR DCD RAI No. 177-1932 Revision 1**

Reference: 1) "Request for Additional Information No.177-1932 Revision 1, SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation, Application Section: 19.2.4.1," dated February 3, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document as listed in Enclosures.

Enclosed is the response to the RAI contained within Reference 1.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittal. His contact information is below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosures:

1. "Responses to Request for Additional Information No. 177-1932 Revision 1"

CC: J. A. Ciocco
C. K. Paulson

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Enclosure 1

UAP-HF-09073
Docket No. 52-021

Response to Request for Additional Information
No.177-1932 Revision 1

March 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 177-1932 REVISION 1**

SRP SECTION: **19 – Probabilistic Risk Assessment and Severe Accident Evaluation**

APPLICATION SECTION: **19.2.4.1**

DATE OF RAI ISSUE: **2/3/2009**

QUESTION NO.: 19-291

DCD Section 19.2.4.1 describes the analysis of ultimate containment pressure capacity and states that the containment capacity is 216 psig. The applicant's calculation for ultimate capacity was performed using a simplified approach (stated to be conservative) and did not use a detailed finite element (FE) model to capture nonlinear material behavior, as recommended in Regulatory Guide 1.136, "Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments." Absent a detailed FE analysis, it is not clear how stress concentrations resulting from structural discontinuities (e.g. containment penetrations, cylindrical shell-to-upper dome interface, and the wall-to-floor interface) are considered in the analysis of ultimate containment pressure capacity.

Further, the Level 2 PRA described in Section 19.1.4.2 uses a simplified calculation of capacity based on hoop direction yielding but it is not clear if a single deterministic value is used or if a probabilistic overpressure capacity (fragility) is used. Typically a Level 2 PRA would require a probabilistic description of the overpressure capacity. If a probabilistic definition of the overpressure capacity was used in the Level 2 PRA, the development of the containment overpressure fragility should be described in Section 19.2.4 of the DCD.

a) Staff requests the applicant to provide a summary of the governing failure modes and design margins relative to the design basis internal pressure for the PCCV for critical areas including the cylindrical shell away from discontinuities, the dome, the cylindrical shell to base mat connection, equipment hatch and personnel air lock.

b) Staff requests the applicant to describe the derivation of the containment overpressure fragility and state whether or not any COL action items are required.

c) DCD Section 19.2.4.1 states that a temperature range of 400~600°F was assumed for severe accident conditions and for the analysis of ultimate containment capacity. However, in this section there is no discussion of the basis for the selection of this temperature range. Further, this section does not discuss the affects of these temperatures on the concrete containment.

To address this concern, the staff requests the applicant to provide a basis for assuming 400~600°F for the severe accident conditions and describe how temperature effects on concrete strength are addressed in the calculation of ultimate pressure capacity of containment.

d) DCD FSAR Section 19.2.4.1 describes the analysis of containment ultimate capacity. However, this section does not state how dead loads are considered in the analysis. RG 1.136, "Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments." states that dead loads should be considered in containment loadings.

To address this concern, the staff requests the applicant to provide a description of how dead loads are considered in the calculation of ultimate pressure capacity of containment.

ANSWER:

(a) The discussion of the ultimate capacity of the PCCV is described in DCD subsection 3.8.1.4.3. In the evaluation of the ultimate pressure capacity of containment, it is assumed that the ultimate structural failure is governed by membrane rupture of the shell at mid-height of the cylinder (tension hoop strain failure not adjacent to any penetrations or discontinuities) with the maximum hoop strain of 1.65% at time of ultimate rupture. This assumption is based on the containment integrity research performed by SNL (Reference 3.8-16). This report by SNL includes the test and analysis results of the pressure capacity of PCCV which has very similar configuration with the US-APWR containment.

The ultimate pressure capacity of the US-APWR containment is evaluated as 201 psig, which is approximately three times greater than the design pressure of containment (Pd), 68 psig. Hence, it can be considered that there is sufficient design margin.

(b) The uncertainty of the containment capability is discussed in Chapter 16 of the PRA technical report (MUAP-07030(R1)), in which the fragility curve for the containment cylindrical shell is presented. However, the derivation of the containment overpressure fragility is not presented in the DCD because no specific requirements for this issue are found in RG1.206. Because of the same reason, MHI does not intend to state the COL action item for derivation of the containment overpressure fragility.

(c) The accident progression analysis result is presented in Chapter 14 of the PRA technical report, in which transition of the containment gas temperature during several postulated severe accident conditions is described. It can be seen from the presented graphs that the highest containment temperature at the containment failure among the various cases is approximately 550°F and mostly it ranges around 400°F. Please see Tables 14-3 to 14-10, in which the actual readings of the containment gas temperature at either containment failure or end of the calculation are presented. The containment temperature shown in Chapter 14 is at the upper dome, and it is assumed that whole containment temperature can be represented by them. It is because the upper dome area is the largest and gas mixture within the containment is good, and hence it can be considered that the whole containment temperature is averaged, more or less homogeneous, at the final phase of the accident progression immediately before the containment failure. It is therefore the temperature range of 400~600°F is assumed for the severe accident conditions and for the analysis of the ultimate containment capacity.

Calculation of the ultimate pressure capacity of the containment is described in DCD Subsection 3.8.1.4.3 and Chapter 16 of the PRA technical report. This calculation is performed in consideration of the yield strength of tendon, rebar and liner, and the concrete is treated as no-tension material. The concrete strength is therefore conservatively ignored in the evaluation of the ultimate pressure capability. And the yield strength of metal materials, i.e. tendon, rebar and liner, is very little affected from the assumed temperature range of 400~600°F in this calculation.

(d) As described in DCD Subsection 3.8.1.4.3 and Chapter 16 of the PRA technical report, the ultimate pressure capacity of containment (201psig), approximately three times greater than the design pressure, is calculated by summing the yield strength of tendon, rebar and liner in membrane hoop tension. In this calculation, dead load is not considered because there is no significant influence on global hoop stress by dead loads. This calculation method is used also in Appendix of Reference 3.8-16. This calculation is considered to be a conservative approach because it does not take credit for redistribution of load or additional strain beyond the yield point of the materials. The real ultimate pressure capacity of containment exceeds the calculated ultimate pressure of containment.

Reference 3.8-16: Containment Integrity Research at Sandia National Laboratories, An Overview, NUREG/CR-6906 (SAND2006-2274P), Sandia National Laboratories, July 2006.

<u>Impact on DCD</u>

There is no impact on DCD from this RAI.

<u>Impact on COLA</u>

There is no impact on COLA from this RAI.

<u>Impact on PRA</u>

There is no impact on PRA from this RAI.