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TOKYO, JAPAN

July 15, 2011
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-11219

Subject: MHI's Responses to US-APWR DCD RAI No. 764-5805 Revision 3 (SRP 19.0)

Reference: 1) "Request for Additional Information No. 764-5805 Revision 3, SRP Section: 19 – Probabilistic Risk Assessment and Severe Accident Evaluation, Application Section: SRP Chapter 19," dated June 6, 2011.

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 one RAI contained within Reference 1. Of these RAIs, two questions #19-529 and #19-530 will not be answered within this package. These questions require additional time for internal discussions and computations, and will be answered by 5th August 2011.

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

Sincerely,

Y. Ogata

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

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NRO

Enclosures:

1. Responses to Request for Additional Information No. 764-5805 Revision 3

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-11219
Docket Number 52-021

Responses to Request for Additional Information
No. 764-5805 Revision 3

July 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/15/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 764-5805 REVISION 0**

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

APPLICATION SECTION: **19.2.4.2**

DATE OF RAI ISSUE: **6/6/2011**

QUESTION NO.: 19-527

Technical report MUAP-10018-P (R0), "US-APWR Containment Performance for Pressure Loads," Section 3.2, states that the effects of pre-stressing were considered in the analysis of the PCCV. Further, Section 3.4, states that the level of pre-stressing is deemed an important parameter in determining the pressure capacity from the global modeling. The applicant indicates that effects of tendon relaxation, concrete creep, and loss of pre-stress at anchorage are factors in pre-stress level. However, no description of these effects is provided in MUAP-10018-P (R0).

To address this issue, staff requests the applicant to provide additional information relating to how the effects of tendon relaxation, concrete creep, concrete shrinkage, and loss at anchorages are considered in the analysis of the PCCV.

ANSWER:

In the design basis of the PCCV, the effects of tendon relaxation, concrete creep, concrete shrinkage, and anchorage losses are considered in calculating a level of prestress after 60 years of operation based on ASME code requirements. In the pressure fragility evaluation, this "end-of-life" prestressing level is considered the 95% confidence value of prestressing, that is, there is 95% confidence level that this level of prestress would be maintained over the life of the structure. For the nominal or best-estimate value of prestress, a level of prestress is used in the fragility analysis based on that calculated for the design basis at SIT conditions, which basically accounts for losses during anchorage seating and some initial tendon relaxation and concrete creep, concrete shrinkage. The prestress levels used for nominal values are about 4% higher than those used for 95% confidence values. The effects of this variation in prestress are considered by performing an analysis with nominal values of all parameters, then another analysis using 95% confidence values of prestressing and nominal values of all other parameters and determining the change in the pressure capacity. The contribution to the variance or "standard deviation" in pressure capacity due to uncertainty in prestress can then be calculated from this difference in the pressure capacity as described in Section 4.3 of the report.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/15/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 764-5805 REVISION 0**

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

APPLICATION SECTION: **19.2.4.2**

DATE OF RAI ISSUE: **6/6/2011**

QUESTION NO.: 19-528

In technical report MUAP-10018-P (R0), "US-APWR Containment Performance for Pressure Loads," Section 3.2, Section 3.9, the applicant describes the reinforced concrete failure criteria used in evaluating the pressure capacity for the containment system. For reinforced concrete, failure is assumed to occur when tensile loads cause rebar to yield and then rupture, or when shear forces across a section exceed the shear capacity. Concrete shear capacity is defined as section shear strains reaching a level of 0.55 percent. While the applicant has cited references for the basis for the 0.55 percent shear strain value, it is not clear to what extent those references are applicable to USAPWR PCCV design.

To address this, the staff requests the applicant to include in the report a summary of the basis for the failure criterion of 0.55 percent shear strain and describe the applicability to the design and loading condition(s) of the US-APWR PCCV.

ANSWER:

The section shear capacity criteria of 0.55% is based on research performed by ANATECH in support of Sandia National Labs for a NRC sponsored study on the seismic capacity of prestressed concrete containment vessels, documented in "Seismic Analysis of a Prestressed Concrete Containment Vessel Model," NUREG/CR-6639, U. S. Nuclear Regulatory Commission, Washington, D. C., August 1999. This study involved a series of shake table tests on a scaled PCCV model performed in Japan, in which increasing levels of seismic loading are applied until eventual failure of the test model occurs. Analytical simulations of these series of tests were performed by ANATECH using the same concrete material model and modeling methods as employed on the pressure fragility calculations. The structural configuration considered is a prestressed concrete containment, very similar to that in the pressure fragility assessment. In the analytical effort simulating the PCCV model tests, a subset of the series of tests were performed to capture the accumulation of damage in the concrete, and the model response and thus level of damage calculated was considered to be in relatively good agreement with the test data. The test model eventually failed in shear, and examination of the analytical model at the failure conditions indicated that about 0.55% shear strain had developed across the wall of the PCCV. This section shear failure criteria has since been applied to deep beam tests that fail in shear and shown to be consistent with these failure conditions. Since shear failure is mainly a function of crack opening such that aggregate interlock and interface friction no longer provide sufficient resistance to shear deformations, this section failure criteria is also considered appropriate for these pressure fragility analyses. That is, the failure criteria is not dependent on the method of loading, just the level of strain that develops across the structural section from any loading. The report will be revised to incorporate above description.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/15/2011

US-APWR Design Certification

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Docket No.52-021

RAI NO.: **NO. 764-5805 REVISION 0**

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

APPLICATION SECTION: **19.2.4.2**

DATE OF RAI ISSUE: **6/6/2011**

QUESTION NO.: 19-531

Staff notes that in SER Section 6.2.5 there is a concern (RAI-449) regarding the potential for hydrogen accumulation within the RWSP. The applicant, in response to RAI 19-449, described several additional analyses on the RWSP sub-compartment. These analyses indicated that hydrogen concentrations greater than 10% by volume may occur. A staff scoping calculation of a hydrogen detonation scenario within the RWSP sub-compartment indicates that a high level of reflected pressure could occur on the adjacent PCCV wall.

Based on the above, staff requests the applicant to perform a structural calculation to demonstrate that the containment structural integrity requirements of 10 CFR 50.44 (c)(5) are satisfied. The applicant's analysis method should be consistent with the methods described in RG 1.216 and account for dynamic effects and material nonlinearities.

ANSWER:

The RWSP hydrogen build-up concern was identified in the RAI 751-5709 (Question 6.2.5-43) and RAI 752-5614 (Question 19-522). The responses to these questions included design options to improve the control of hydrogen during a severe accident, as well as the self-evaluation for conformance to the related regulatory requirements, regulatory guides and the NRC safety goals.

The necessity to perform a containment structural integrity calculation addressing the hydrogen detonation scenario within the RWSP will be determined when the NRC will complete reviewing the response to the above mentioned and the forthcoming follow-up RAI questions.

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.