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July 7, 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-09357

Subject: MHI's Responses to US-APWR DCD RAI No. 382-2409 Revision 0

Reference: [1] "Request for Additional Information No. 382-2409 Revision 0, SRP Section: 09.01.01 - Criticality Safety of Fresh and Spent Fuel Storage and Handling - Design Certification and New License Applicants, Application Section: 9.1.1," dated June 8, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 382-2409 Revision 0".

Enclosure 1 is the responses to 11 questions that are contained within Reference [1].

As replied to Question 09.01.01-11 in Enclosure 1, the technical report MUAP-07032-P (R0) which was submitted to the NRC in February 2008 is subject to be revised due to the final selection of neutron absorbing material of spent fuel storage rack. The new calculation is being implemented basically same protocol and conditions to those of previous technical report, incorporating selected material properties and sub-supplier's (Holtec) standardized and the NRC accepted racks in U.S. operating plants.

The revised report will be submitted to the NRC in August, 2009. It is believed that the revised report will specifically further resolve all questions contained in this RAI.

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. 382-2409 Revision 0

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

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Enclosure 1

UAP-HF-09357
Docket No. 52-021

Responses to Request for Additional Information
No. 382-2409 Revision 0

July 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 382-2409 REVISION 0**

SRP SECTION: **9.1.1 – Criticality Safety of Fresh and Spent Fuel Storage and Handling**

APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-11

The US-APWR Tier 2 DCD, Revision 1, Chapter 9 references MUAP-07032-P (R0), Criticality Analysis for US-APWR New and Spent Fuel Storage Racks (Reference 9.1.7-6 in Chapter 9 of the DCD, Revision 1). The following questions are asked against the MHI technical report MUAP-07032. Answers to these questions are needed to support review of DCD Section 9.1.1 in accordance with SRP Section 9.1.1.

In the event of a hypothetical accident that upsets the orderly rack structure, disrupting the configuration of the stored elements (i.e. seismic event), is there an arrangement of either new or spent fuel assemblies (flooded or dry) that could conceivably be more reactive than that for the orderly configuration imposed by the rack storage?

ANSWER:

Prior to reply the captioned question, it must be explained the historical background of our technical report MUAP-07032-P (R0) February 2008 which is subject to be revised due to the final selection of neutron absorbing material of fuel storage racks of the standard US-APWR.

The technical report MUAP-07032-P (R0) was the criticality analysis of the new and spent fuel racks of the US-APWR which has been developed based on Japanese APWR. MHI typically utilize borated stainless steel racks in Japan, therefore, the initial technical report was provided based on the use of borated stainless steel racks as well. However, application of borated stainless steel racks are much less accepted in the U.S., MHI chose to utilize the Holtec standardized and NRC-accepted racks of current U.S. design.

Therefore, the technical report is subject to be revised, incorporating Holtec calculations based on the use of the Metamic neutron absorber. Those calculations were implemented basically same protocol and conditions to previous technical report, considering the material changes. Refer to MHI's response to RAI No. 247-2179, questions 09.01.01-09, for information regarding the final selection of neutron absorbing material of the US-APWR.

Following is the response to the first question of this RAI. It is believed that the revised technical report MUAP-07032-P (R1) report will specifically further resolve all questions contained in this RAI.

The postulated accidental events that potentially upset the fuel rack structure, such as seismic event and fuel drop accident were evaluated if they would significantly impact on criticality safety. In results, there is no significant reactivity effect from any of postulated accidents.

The revised report will provide further information associated with postulated accidents in terms of criticality safety.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-12

The rack design assumes a 17x17 fuel assembly design with particular fissile, fertile and burnable poison material loadings. Are these limiting requirements? How big a perturbation from the base design can be tolerated before a violation of the regulatory requirements is incurred?

ANSWER:

The MHI fuel assembly is basically composed of uranium oxide. And optionally, gadolinium oxide and/or borosilicate glass called burnable poison (BP) is used as a burnable absorber. Gadolinium is an integral type and the BP is insertion type into guide thimble. Those details are described in the DCD subsection 4.3.2.1.

The MHI rack criticality design is based on the fresh fuel assumption of uranium oxide fuel using the maximum allowable fuel enrichment of 5wt% and without taking credit for any burnable absorbers.

This assumption gives the largest Keff and no limiting requirements exist. Therefore, no violation of the regulatory requirements occurs.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-13

Data is given for "flooding and optimum moderation" with regard to reactivity of fresh fuel. How do these results and analyses vary with fuel pin content?

ANSWER:

10 CFR 50.68 requires that the new fuel rack be evaluated for flooding and optimum moderation conditions. Therefore, we described both results. As our assumption of fuel content is the severest condition, other condition of fuel pin content gives only lower keff.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-14

Provide a description of the method used to determine which uncertainties and tolerances were included in the analysis.

ANSWER:

Basically, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants" (U.S. NRC, February 1998) is considered. Section 2 in the document states as follows:

> "Uncertainties (means manufacturing and calculational uncertainties) should be determined for the proposed storage facilities and fuel assemblies to account for tolerances in the mechanical and material specifications. An acceptable method for determining the maximum reactivity may be either (1) a worst-case combination with mechanical and material conditions set to maximize keff or (2) a sensitivity study of the reactivity effects of tolerance variations. If used, a sensitivity study should include all possible significant variations (tolerances) in the material and mechanical specifications of the racks; the results may be combined statistically provided they are independent variations. Combinations of the two methods may also be used."

For NFR, we chose the method (1), worst case model, so as to give maximum keff directly for every water density calculated, fully flooded and optimum moderation.

For SFR, we chose the combination of the two methods. For conservativeness, method (1) was used for the neutron absorber materials; B-SS plate thickness and its boron concentration is set to minimum. All other tolerances were treated by method (2) where the reactivity of the variations were statistically combined.

These are described in 2.1.2.1 and 3.1.2.1

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-15

What procedures are in place to assure that the new fuel rack storage pit does not flood, and that the drains are never blocked or flow out of them impeded in any way?

ANSWER:

In DCD Subsection 9.1.2.2.1, New Fuel Storage, the third paragraph discusses design feature of drain system of the new fuel storage pit, and it will be revised correctively as per MHI's response to associated NRC's question No. 09.01.02-04 in the RAI-132(SBPA-1538) as follows:

> "The new fuel storage pit is provided with a ~~manually operated~~ drain system, which is connected to the R/B sump to prevent the new fuel pit from being flooded by an unanticipated release of water. The design of the drain piping system includes a check valve to ~~prevents~~ backflow into the new fuel pit storage area through the drain system."

In addition, see following MHI's response to associated NRC's question No.09.01.02-03 in the RAI-132(SBPA-1538), which discusses how the design of the drain system protect the new fuel storage pit from postulated maximum flooding in the area.

> "The New Fuel Storage Vault or "New Fuel Pit" (NFP) of the US-APWR is surrounded by a dike to prevent unanticipated water from entering the pit. This area enclosed by the dike will include terminal connections and piping sized ¾ inches to 1 inch. for demineralized water.
>
> The expected US-APWR design utilizes a NFP drain consisting of a funnel leading to a 3 inch pipe (not finalized and subject to change if necessary).
>
> Therefore, the NFP vault device will handle the maximum flow from any water piping in the area.
>
> From the criticality safety perspective, the criticality analysis was performed under NFP conditions assuming it is filled by a water/air from mixture that is the most severe with respect to potential new fuel criticality."

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-16

What is the sensitivity of the multiplication factor to water temperature? If the water temperature should drop below room temperature, what is the effect on the multiplication factor?

ANSWER:

Water density is the key parameter to vary the multiplication factor (keff) when water temperature changes. The maximum water density at 39.2°F (4°C) gives maximum keff.

In the analysis, a water density of 62.43 lb/ft^3 ($1.0g/cm^3$) is used which covers the maximum water density. This assumption is described in the subsection 2.2.1.3 for NFR and 3.2.1.3 for SFR of MUAP-07032.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION: 9.1.1

DATE OF RAI ISSUE: 06/08/2009

QUESTION NO.: 09.01.01-17

What are the numerical values that go into determining ◘ kc, and where do they come from?

ANSWER:

In section 2.1.2 following equation 3 it states:

> "Δk_c=0.0030 multiplied by benchmarking confidence coefficient of 1.899 at 95 percent probability"

In section 1.1 it states:

> "Code validation have been conducted analyzing criticality experiment of 120 cases and drawn up in the report "Validation of MHI Criticality Safety Methodology (MUAP-07020)" (Reference [8]). Based on this validation, bias and uncertainty of MCNP Code to be taken into consideration for criticality analysis are 0.0029, 0.0030 respectively. The One-sided tolerance limit factor to be multiplied by this uncertainty at a 95 percent probability, 95 percent confidence level is 1.899."

Refer MUAP-07020 which has been provided and reviewed by the NRC.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-18

Burnable poisons are referred to under "Assumptions on Fuel Assembly". What poisons are used? Where are they located? If they are not included in the analysis, what takes their place in the description of the fuel assembly? Was the analysis technique validated for use with poisoned assemblies?

ANSWER:

This question and answer is basically the identical one for burnable poison in the QUESTION NO.: 09.01.01-12. Types of the burnable poisons used and assumptions in the analysis are mentioned there. The locations of burnable poisons are illustrated in Figure 4.3-1 of DCD subsection 4.3.2.1.

Burnable absorbers reduce the reactivity of the fresh fuel. Ignoring them in the analysis is conservative. The "Assumptions of Fuel Assembly" in MUAP-07032 states that "the fresh UO_2 fuel assembly without burnable absorber is assumed to have a maximum enrichment of five weight percent, which is pursuant to 10 CFR 50.68 (b) item (7)". Therefore code validation in MUAP-07020 does not require poisoned assemblies.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-19

How is the boron introduced in the spent fuel storage cooling system? What other accident scenarios are considered besides boron dilution? How are the scenarios determined?

ANSWER:

Initial injection of boric acid water to the SFP is via safety-related piping connections from the seismic category I refueling water storage pit (RWSP) containing a uniform boric acid concentration of 4000 ppm. Boric acid water makeup needs throughout system operation is accomplished by injection from the RWSP. Connections are also available from the refueling water auxiliary storage tank (RWSAT) that has a common header with the RWSP to the SFP. Temporary makeup connections are also available when concentrated boric acid is needed for makeup from the boric acid blender in the chemical and volume control system (CVCS).

The only credible scenario that could diminish the boric acid content in the spent fuel pit (SFP) during normal operation is the potential leakage through tears in the SFP stainless steel lining welds. However, the leakage volume is not expected to result in significant amounts as a leakage detection system is set up for immediate notification to the operator. Isolation valves between the SFP welds leakage collection and the discharge pathways to the sump are also installed to prevent undesirable loss of SFP boric acid water inventory.

There is no credible accident scenario that could diminish the boric acid content in the SFP.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **06/08/2009**

QUESTION NO.: 09.01.01-20

Fuel in the Spent Fuel Racks is "assumed to be loaded with fuel of the maximum fuel assembly reactivity". If fuel is discharged at the burnup point when the burnable poison is burned out, what is the contribution of the trans-uranics to the reactivity? How does the reactivity vary with burnup and boron concentration in the water?

ANSWER:

The assumption of fuel stated in MUAP-07032 is that "the fresh UO_2 fuel assembly without burnable absorber is assumed to have a maximum enrichment of five weight percent, which is pursuant to 10 CFR 50.68 (b) item (7)".

Therefore the fuel reactivity monotonously decreases with increase in burnup and boron concentration in the water.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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SRP SECTION: 9.1.1 – Criticality Safety of Fresh and Spent Fuel Storage and Handling

APPLICATION SECTION: 9.1.1

DATE OF RAI ISSUE: 06/08/2009

QUESTION NO.: 09.01.01-21

Why are reflecting boundary conditions used in the series of calculations used to determine the uncertainty associated with fuel assembly placement within the SFR? Would a periodic boundary condition not be more appropriate, and if not why not?

ANSWER:

Reflective boundary is correct because the purpose of this model is to simulate the condition that the 4, 16 and 36 assemblies in a block gather in the center of the block.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.