MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

August 31, 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-11288

Subject: MHI's Responses to US-APWR DCD RAI No.794-5871 Revision 0 (SRP 6.5.2)

References: 1) "Request for Additional Information No. 794-5871 Revision 0, SRP Section: 06.05.02, Application Section: 6.5.2," dated (August 1,2011).

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "MHI's Response to US-APWR DCD RAI No. 794-5871 Revision 0".

Enclosed are the responses to four RAIs contained within Reference 1.

As indicated in the enclosed materials, this document contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. A non-proprietary version of the document is also being submitted with the information identified as proprietary redacted and replaced by the designation "[ ]".

This letter includes a copy of the proprietary version (Enclosure 2), a copy of the non-proprietary version (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all materials designated as "Proprietary" in Enclosure 2 be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

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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Enclosures:

1. Affidavit of Yoshiki Ogata

2. MHI's Response to US-APWR DCD RAI No. 794-5871 Revision 0 (proprietary)

3. MHI's Response to US-APWR DCD RAI No. 794-5871 Revision 0 (non-proprietary)

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

<u>Contact Information</u>

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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-11288

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, LTD ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled MHI's Response to US-APWR DCD RAI No. 794-5871 Revision 0" dated August 31, 2011, and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those pages containing proprietary information are identified with the label "Proprietary" on the top of the page and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information identified as proprietary in the enclosed document has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the unique design of the safety analysis, developed by MHI (the "MHI Information")

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market:

A. Loss of competitive advantage due to the costs associated with unique design parameters.

B. Loss of competitive advantage of the US-APWR created by benefits of [approach to justification for post accident pH control system design.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed on this 31st day of August, 2011.

Y. Ogata

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

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Enclosure 3

UAP-HF-11288
Docket Number 52-021

MHI's Response to US-APWR DCD RAI No. 794-5871 Revision 0

August 2011
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

8/31/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**794-5871 REVISION 0**
SRP SECTION:	**06.05.02 – CONTAINMENT SPRAY AS A FISSION PRODUCT CLEANUP SYSTEM**
APPLICATION SECTION:	**DCD Section 6.5.2, 15.6.5 and 15A**
DATE OF RAI ISSUE:	**8/1/2011**

QUESTION NO.: 06.05.02-10

In the April 18, 2011 response to RAI 715-5262, Question 06.05.02-9, the applicant provided a table with the major input parameters used in the RWSP water pH analysis. In the case of the base case value for the NaTB concentration in the RWSP, the staff considers the number unrealistic, as the concentration of NaTB is expected to be higher. Provide an explanation of how the value was obtained.

ANSWER:

The units for “NaTB Concentration in RWSP (ppm)” in Table 1 of the response to RAI 715-5262, Question 06.05.02-9, Rev.0, are not correct. The units should be “mol/L” instead of “ppm.”

Also, the Base Case value listed in Table 1 of the response to RAI 715-5262, Rev.0, is not correct. The value listed below the response to RAI 794-5871, Rev.0, was actually used in the calculation in the response to RAI 715-5262, Rev.0.

The NaTB concentration of[ ]mol/l for the realistic case is derived as follows:

[ ]

*1 NaTB mass

*2 Molecular weight of NaTB ($Na_2B_4O_7 \cdot 10H_2O$)

*3 Recirculation Water Volume for pH analysis

NaTB concentration of base case is 0.0142 [mol/l] and has[ ]
Therefore, NaTB Concentration in Table 1 of previous response is corrected as follows:

Parameters	**Value**	
	Base Case	**Realistic iodine re-evolution**
NaTB concentration in RWSP (mol/l)	0.0142	[ ]

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

8/31/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**794-5871 REVISION 0**
SRP SECTION:	**06.05.02 – CONTAINMENT SPRAY AS A FISSION PRODUCT CLEANUP SYSTEM**
APPLICATION SECTION:	**DCD Section 6.5.2, 15.6.5 and 15A**
DATE OF RAI ISSUE:	**8/1/2011**

QUESTION NO.: 06.05.02-11

In the response to RAI 715-5262, Question 06.05.02-9, the concluding sentence states: "Therefore, it is not necessary to include iodine re-evolution in the design basis." The staff considers that the response to the RAI itself constitutes an evaluation of iodine re-evolution. Please explain the basis for this statement.

ANSWER:

The dose analysis in DCD Ch.15 is used as the design basis evaluation for the US-APWR licensing basis, and does not include iodine re-evolution from the RWSP. However, as shown in the response to RAI 715-5262, Question 06.05.02-9, Rev.0, each parameter in the DCD Ch. 15 dose analysis is set conservatively. As a result, the dose analysis in DCD Ch.15 results in more severe radiological consequences than the realistic dose analysis with iodine re-evolution discussed in the response to RAI 715-5262, Rev.0 (see Table 1). This indicates that the DCD Ch. 15 evaluation includes sufficient conservatisms and margin to bound the realistic impact of iodine re-evolution.

Therefore, it is not necessary to include iodine re-evolution in the DCD Ch. 15 dose analysis.

Table 1. Comparison of DCD Ch. 15 Rev. 3 Dose Analysis to
Realistic Dose Analysis with iodine re-evolution

	Licensing Dose Analysis in DCD Chapter 15 Rev.3 (rem)	Realistic Dose Analysis with Iodine Re-evolution (rem)
Exclusion Area Boundary	13	
Outer Boundary of Low Population Zone	13	
Main Control Room	4.6	

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

8/31/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**794-5871 REVISION 0**
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APPLICATION SECTION:	**DCD Section 6.5.2, 15.6.5 and 15A**
DATE OF RAI ISSUE:	**8/1/2011**

QUESTION NO.: 06.05.02-12

Regarding the realistic dose analysis modeling of containment leakage provided in the response to RAI 715-5262, Question 06.05.02-9:

a. Provide the basis and/or rationale for the assumed percentage of direct environmental leakage (bypass of secondary containment and filtration),

b. Provide a reference for, or a derivation of, the time-dependent containment leak formula.

ANSWER:

a.

The pipes which penetrate containment have isolation valves, and the containment atmosphere during a LOCA is prevented from being released to the environment.

The containment concrete shell inner surface is lined with a minimum 1/4-in. carbon steel plate that is anchored to the concrete shell and dome to provide the required pressure boundary leak tightness. Therefore, it is expected that leakage from containment occurs through piping and other penetration areas, which are enclosed by the Penetration Area and Safeguard Component Area (PASCA). In general, leakage from containment to other areas is expected to be negligible because of high levels of quality assurance in construction and periodic inspections and leakage testing of the containment volume and penetrations.

All containment penetration parts are enclosed by the PASCA. Therefore, all leakage through penetrations enters the PASCA. The Engineered Safety Features Ventilation system maintains the PASCA at negative pressure during design basis accidents, thereby preventing the leakage from traveling to other areas.

Leakage released to the environment in the US-APWR design was calculated assuming all leakage to the PASCA is released to the environment until these areas attain negative pressure, which occurs in about 4 minutes. Bypass leakage (bypassing the PASCA and passing through to the environment) was calculated for the installed piping penetration parts without crediting the airtightness of piping penetration components. Bypass leakage was assumed from isolation valves on these pipes and calculated using specified design-basis limits for the US-APWR design. Based on BRANCH TECHNICAL POSITION 6-3 Rev.3 (Ref. 1), leakage from piping penetrations which consist of closed systems was excluded from the bypass leakage calculation.

Calculated bypass leak rate corresponds to about [ ] of total containment leak rate. And, this is sufficiently less than [ ] of total containment leak rate [*1].

*1 Even though calculated bypass leakage might be changed as the US-APWR design progresses, containment leak rate is designed so that bypass leakage does not exceed [ ] of containment leak rate.

From discussion above, direct bypass leakage from containment to the environment is assumed to be [ ] of containment leak rate in the realistic dose analysis.

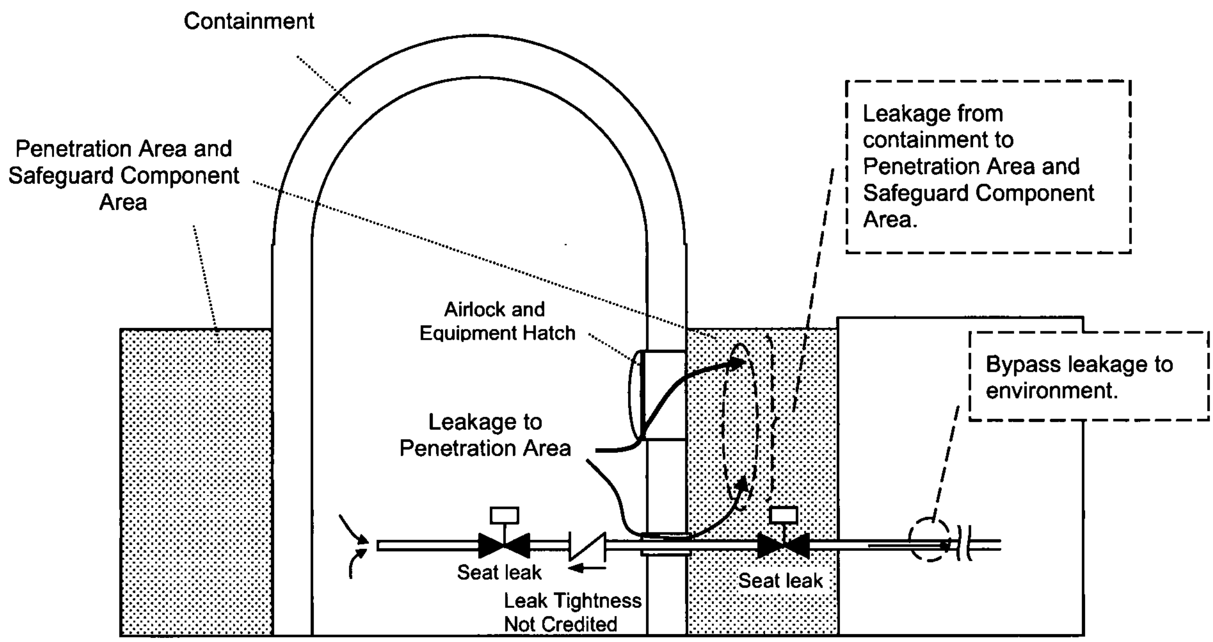

Figure 1. Example of Bypass Leakage Pathway

b.

The steps for deriving the time-dependent containment leak formula in the response to RAI 715-5262, Question 06.05.02-9, Rev.0, are as follows:

The leak flow from the containment is not considered to be choked since the upstream containment pressure including accident condition is sufficiently lower than the critical pressure necessary for choked flow. Therefore, the leak mass flow rate from the containment can be expressed as the following pressure difference equation:

$$m = C \cdot \sqrt{\Delta P \cdot \rho} \qquad \text{(Eq. 1)}$$

where m is leak mass flow rate, C is a constant discussed below, ΔP is differential pressure between the inside and outside of the containment, and ρ is the mean density of atmosphere in the containment.

By dividing m by the total mass of containment internal gases M, Eq.2 gives the containment leak rate L:

$$L = \frac{m}{M} = \frac{m}{V \cdot \rho} = C' \cdot \sqrt{\frac{\Delta P}{\rho}} \qquad \text{(Eq. 2)}$$

where M is the total mass of containment internal gases, V is the gas volume in the containment, and C' represents C/V, which is treated as constant for the same plant.

The realistic containment leak rate during accident conditions can be estimated by using the C' obtained from the design leak rate.

The design leak rate L_d, which will be verified through periodic testing, is defined as 0.1 %/d (Ref. 2) at test conditions. 10 CFR 50 Appendix J (Ref. 3) provides that the pressure referred to the design leak rate should be the calculated peak containment pressure P_a. However, the design pressure P_d, 68 psig (Ref. 2), is assumed as the reference pressure of the design leak rate, since P_a may vary with the design progress. For this design leak rate, Eq. 2 can be rewritten as:

$$L_d = C' \cdot \sqrt{\frac{\Delta P_d}{\rho_d}} \qquad \text{(Eq. 3)}$$

where ΔP_d is differential pressure between the design pressure and outside of the containment, and ρ_d is the mean density of air in the containment at the minimum temperature (Ref. 3) and the design pressure for conservatively high value of C'. ρ_d is also obtained by the ideal gas equation as follows:

$$P_d V = R \cdot M_d \cdot T_d$$

$$P_d = R \cdot \left(\frac{M_d}{V}\right) \cdot T_d$$

$$P_d = R \cdot \rho_d \cdot T_d$$

$$\rho_d = \frac{P_d}{R \cdot T_d} \qquad \text{(Eq. 4)}$$

where R is the gas constant and T_d the minimum containment temperature. By applying Eq. 4 to Eq. 3, C' is given by:

$$C' = \frac{L_d}{\sqrt{\Delta P_d / \rho_d}} = L_d \sqrt{\frac{P_d}{R \cdot T_d \cdot \Delta P_d}} . \qquad \text{(Eq. 5)}$$

By substituting Eq. 5 into Eq. 2, the containment leak rate L during an accident can be obtained as the following time-dependent containment leak formula:

$$L = L_d \sqrt{\frac{1}{RT_d} \frac{\Delta P_t}{\rho_t} \frac{P_d}{\Delta P_d}} \qquad \text{(Eq. 6)}$$

where, subscript t means time-dependent value during accident conditions. ΔP_t and ρ_t are calculated under the LOCA limiting condition addressed in DCD subsection 6.2.1.3 (Ref. 4)

References

1. STANDARD REVIEW PLAN BRANCH TECHNICAL POSITION 6-3 Rev.3, March 2007 "DETERMINATION OF BYPASS LEAKAGE PATHS IN DUAL CONTAINMENT PLANTS",
2. Table 6.2.1-2, DESIGN CONTROL DOCUMENT FOR THE US-APWR Chapter 6, Engineered Safety Features, MUAP-DC006 Revision 3, March 2011
3. Codes and Standards, Title 10, Code of Federal Regulation, 10 CFR 50 Appendix J, January 2007 edition.
4. Subsection 6.2.1.5.3, DESIGN CONTROL DOCUMENT FOR THE US-APWR Chapter 6, Engineered Safety Features, MUAP-DC006 Revision 3, March 2011
5. Subsection 6.2.1.3, DESIGN CONTROL DOCUMENT FOR THE US-APWR Chapter 6, Engineered Safety Features, MUAP-DC006 Revision 3, March 2011

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

8/31/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**794-5871 REVISION 0**
SRP SECTION:	**06.05.02 – CONTAINMENT SPRAY AS A FISSION PRODUCT CLEANUP SYSTEM**
APPLICATION SECTION:	**DCD Section 6.5.2, 15.6.5 and 15A**
DATE OF RAI ISSUE:	**8/1/2011**

QUESTION NO.: 06.05.02-13

Describe in more detail how the values in Table 3 of the response to RAI 715-5262, Question 06.05-02-9, were calculated. The response should include at a minimum:

a. How was the graph of iodine re-evolution as fraction of iodine in the recirculation water given in RAI response Figure 4 converted to input values of iodine released as a fraction of core iodine for use in RADTRAD? Give the basis for assumptions used.

b. State which curve from RAI response Figure 4 was used, and why.

c. In the licensing basis LOCA dose analysis, some iodine removal through natural processes is also credited. Would this additional potential iodine source to the recirculation water significantly change the iodine re-evolution fraction used in the RAI response realistic dose analysis?

ANSWER:

The methodology for calculating the iodine re-evolution fraction is shown in the response to RAI 715-5262, Question 06.05.02-9, Rev.0, and the derivation of values in Table 3 of the response is shown in Item a. Responses for Item a, b and c are shown below.

<u>a.</u>

The result of iodine re-evolution was assumed to be a linear function. “Fraction” in Figure 4 in the response to RAI 715-5262, Rev.0, refers to iodine re-evolution fraction versus 40% of iodine in the core, where 40% of iodine in core is the total iodine released into containment. In order to derive the iodine re-evolution fraction for dose analysis input, the linear iodine re-evolution fraction was multiplied by the total released iodine fraction into containment. The resulting values are shown in Table 3 in the response to RAI 715-5262, Rev.0.

The re-evolution fraction increases [

]

Linear iodine re-evolution fraction and conversion to realistic dose analysis input are shown in Figure 2 below.

[

Note) 40% of iodine in core means total iodine released into containment

]

Figure 2. Conversion to Realistic Dose Analysis Input of Iodine Re-evolution

b.

Figure 4 in the response to RAI 715-5262, Question 06.05.02-9, Rev.0, has two curves. The "Base Case" curve is the result for the base case, and the "Modified" curve is the result for the realistic case. The "Modified" curve is used for the realistic dose analysis with iodine re-evolution discussed in the response to RAI 715-5262, Rev.0.

c.

In evaluation of iodine re-evolution, 95% of the iodine (all the particulate) released into containment is assumed to contribute to iodine in recirculation water, and the remaining 5% (elemental and organic forms) of the released iodine is assumed not to transfer to recirculation water. Even if this 5% of released iodine were included in the total iodine in the recirculation water the iodine re-evolution fraction would at best increase by 5%. Hence, the peak re-evolution fraction would only change slightly from [.] to about[ ].

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.