MITSUBISHI HEAVY INDUSTRIES, LTD.
16-5, KONAN 2-CHOME, MINATO-KU
TOKYO, JAPAN

September 7, 2012

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-12241

Subject: MHI's Response to US-APWR DCD RAI No. 952-6333 (SRP 04.04)

References: 1) "Request for Additional Information No. 952-6333", dated August 10, 2012

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. 952-6333. "

Enclosed is the response to the question 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) of the response, a copy of the non-proprietary version (Enclosure 3) of the response, 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 Mr. Joseph Tapia, General Manager of Licensing Department, 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,
Director, APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

D081
NRO

Enclosures:

1. Affidavit of Yoshiki Ogata

2. Response to Request for Additional Information No. 952-6333 (Proprietary version)

3. Response to Request for Additional Information No. 952-6333 (Non-proprietary version)

CC: J. A. Ciocco
J. Tapia

Contact Information
Joseph Tapia, General Manager of Licensing Department
Mitsubishi Nuclear Energy Systems, Inc.
1001 19th Street North, Suite 710
Arlington, VA 22209
E-mail: joseph_tapia@mnes-us.com
Telephone: (703) 908-8055

ENCLOSURE 1

Docket No. 52-021
MHI Ref: UAP-HF-12241

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am Director, 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 "Response to Request for Additional Information No. 952-6333" dated September 2012, 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 information of thermal design methodology developed by MHI and not used in the exact form by any of MHI's competitors. This information was developed at significant cost to MHI, since it required the performance of research and development and detailed design for its software and hardware extending over several years.

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 development of the thermal design. Providing public access to such information permits competitors to duplicate or mimic the methodology without incurring the associated costs.

B. Loss of competitive advantage of the US-APWR created by benefits of enhanced plant safety, and reduced operation and maintenance costs associated with the thermal 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 7th day of September, 2012.

Yoshiki Ogata,
Director, APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Docket No. 52-021
MHI Ref: UAP-HF-12241

Enclosure 3

UAP-HF-12241
Docket No. 52-021

Response to Request for Additional Information No. 952-6333

September 2012
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/7/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 952-6333 REVISION 0**
SRP SECTION:	**04.04 – THERMAL AND HYDRAULIC DESIGN**
APPLICATION SECTION:	**4.4**
DATE OF RAI ISSUE:	**8/10/2012**

QUESTION NO.:04.04-42

The applicant response to RAI Question 04.04-2 in UAP-HF-09336, dated June 25, 2009, provided the basis for using less than 1% for rod bow penalty. Provide the delta bow calculation used to determine the penalty.

ANSWER:

The evaluation of the rod bow penalty (δ_{bow}) for US-APWR utilizes the methodology described in Reference 04.04.42-1, which was approved by the NRC in 1979. The methodology is summarized as follows, and a detailed description is provided in Reference 04.04.42-2.

(1) A probability distribution of a rod-to-rod gap closure ratio is obtained for the specified assembly-average fuel burn-up.
(2) A relationship between departure from nucleate boiling ratio (DNBR) reduction and the gap closure ratio is given by a correlation derived from departure from nucleate boiling (DNB) test data with a bowed rod.
(3) The probability distribution of the DNBR reduction obtained from (1) and (2) is statistically combined with the probability distribution of the minimum DNBR using Monte-Carlo calculation. The resulting probability distribution is used for determining a new DNBR Design Limit (DL) that accounts for the rod bow effect.
(4) The percentage difference between the DLs with and without rod bow is defined as the rod bow penalty.

A detailed calculation is provided below.

(1) The probability distribution of the rod-to-rod gap closure ratio used for the US-APWR is a normal distribution with the mean value μ_c=[ ] and standard deviation σ_c=[ ], which was evaluated as the 95/95 basis value for 14ft fuel with 11 grid spaces at the assembly-average burn-up of [ ]. This distribution was evaluated from the burn-up dependent standard deviation curve of the gap closure ratio obtained based on the fuel inspection data after irradiation, and includes a multiplier of [ ] to account for margin including cold-to-hot conversion of gap closure ratio. Due to the fact that the standard deviation increases with fuel burn-up, the

assembly average burn-up of [ ] is selected in order to conservatively cover the burn-up of the hot fuel assembly in the US-APWR core. Both the selection of the fuel burn-up condition and margin for cold-to-hot conversion is considerably more conservative when compared to the methodology approved in Reference 04.04.42-1.

(2) The correlation to estimate the DNBR reduction (δ) from the gap closure ratio $\Delta C/C_0$ and plant operation parameters takes the following form:

[ ] (1)

Where:

[ ]

The DNBR reduction (δ) is evaluated using conservative conditions. For $\delta_{85,}$ [ ]. For $\delta_{con,}$ [ ].

[ ]

The evaluation of δ_{85} and δ_{con} gives [ ] and [ ] DNBR reduction, respectively.

[ ]

(3) The US-APWR design utilizes the Revised Thermal Design Procedure (Reference 04.04.42-3), where the probability distribution of the minimum DNBR is evaluated in terms of a joint statistical variable ***Z*** defined as:

$$Z = DNBR \times (M/P),$$

Where:

- ***DNBR*** is a statistical variable derived from a statistical combination of the input parameters by the sensitivity coefficient method;
- ***M/P*** is the ratio of measured to predicted critical heat flux based on DNB test database.

The distribution of joint statistical variable ***Z*** is evaluated by linear approximation and conservatively-selected sensitivity factors. The detailed evaluation is presented in Reference 04.04.42-4. The resulting ***Z*** has a normal distribution represented by the mean μ_z, and the standard deviation σ_z, as indicated in Table 1. The design limits of the minimum DNBR without rod bow effect (DL_{UNBOW}) are determined as the ratio of the $DNBR_{NOM}$ to the lowest value of ***Z*** at 95/95 basis, $\boldsymbol{Z_{95}}$.

$$DL_{UNBOW} = \left[\quad \right]$$

The probability distribution, including the rod bow effect $\boldsymbol{Z_{bow}}$, is generated by Monte-Carlo calculation where a random sample of δ is combined with a random sample from ***Z*** in the following form:

$$Z_{bow} = (1-\delta)Z .$$

A sample value of $\Delta C/C_0$ is obtained by taking a larger value from a pair of random rod-to-rod gap closure value, and the resulting $\Delta C/C_0$ is substituted into Equation (1) to evaluate δ. This procedure accounts for selecting larger rod-to-rod gap from two sides of a single rod.

The Monte-Carlo calculation was performed with [ ] samples, and the mean and standard deviation of resulting $\boldsymbol{Z_{bow}}$, which are represented by $\mu_{z,BOW}$ and $\sigma_{z,BOW}$, respectively, are shown in Table 2. $Z_{95,BOW}$, that is the 95/95 lowest value of $\boldsymbol{Z_{bow}}$, is represented by the [ ] of the samples. Note that the probability distribution of $\boldsymbol{Z_{bow}}$ is non-symmetric around the mean value because of the asymmetry of the δ distribution. The DNBR design limits including the rod bow effect are determined using:

$$DL_{bow} = \left[\quad \right]$$

(4) The rod bow penalty (δ_{bow}) is defined as the percent difference between DL_{bow} and DL_{unbow}:

$$\delta_{bow} = 1 - \frac{DL_{UNBOW}}{DL_{BOW}}.$$

The results of δ_{bow} calculation are shown to be less than 1 % as presented in Table 2.

Table 1:Design Values for RTDP

	Typical cell	Thimble cell
$\mu_{M/P}$		
μ_z		
σ_z		
DL_{UNBOW}		

Table 2: Design Values for Rod Bow Penalty Evaluation

	Typical cell	Thimble cell
$DNBR_{NOM}$		
$\mu_{z,BOW}$		
$\sigma_{z,BOW}$		
$Z_{95,BOW}$		
DL_{BOW}		
δ_{bow}		

REFERENCES:

04.04.42-1 Skaritka, J., Ed., "Fuel Rod Bow Evaluation", WCAP-8691 Revision 1, 1979.

04.04.42-2 Letter from Y. Ogata (MHI) to J. A. Ciocco (NRC), "Response to the NRC Request Additional Information on "Thermal Design Methodology" MUAP-07009 Rev.0", UAP-HF-09500, dated October 30, 2009.

04.04.42-3 Friedland, A. J. and Ray, S., "Revised Thermal Design Procedure", WCAP-11397-P-A, 1989.

04.04.42-4 Letter from Y. Ogata (MHI) to J. A. Ciocco (NRC), "MHI's Responses to US-APWR DCD RAI No. 377-2629 Revision 1", UAP-HF-09336, dated June 25, 2009.

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/Topical Report

There is no impact on Technical/Topical reports.