Original

MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

February 10, 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-09049

Subject: MHI's responses to US-APWR DCD RAI No.155-1442 Revision 0

Reference: 1) "REQUEST FOR ADDITIONAL INFORMATION NO. 155-1442 REVISION 0, SRP Section: 09.01.01 - Criticality Safety of Fresh and Spent Fuel Storage and Handling," dated January 14, 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 are the responses to 8 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. Responses to Request for Additional Information No. 155-1442 Revision 0 (proprietary version)

3. Responses to Request for Additional Information No. 155-1442 Revision 0 (non-proprietary version)

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

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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-09049

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 Responses to Request for Additional Information No. 155-1442 Revision 0 dated February 2009, 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 and methodology developed by MHI for performing the design of the US-APWR reactor.

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 methodology related to the analysis.

B. Loss of competitive advantage of the US-APWR created by benefits of modeling information.

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 10th day of February, 2009.

Y. Ogata

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

Enclosure 3

UAP-HT-09049
Docket Number 52-021

Responses to Request for Additional Information No. 155-1442
Revision 0

February 2009
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: NO.155-1442 REVISION 0

SRP SECTION: 09.01.01 - CRITICALITY SAFETY OF FRESH AND SPENT FUEL STORAGE AND HANDLING

APPLICATION SECTION: 9.1.1

DATE OF RAI ISSUE: 1/14/2009

QUESTION NO. : 09.01.01-1

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). This report, in turn, references ([8] in section 5.0) the MHI technical report MUAP-07020 (R0), Validation of the MHI Criticality Safety Methodology. This question and the following questions are asked against the MHI technical report MUAP-07020. Answers to these questions are needed to support the review of DCD section 9.1.1 in accordance with the SRP section 9.1.1.
[Page 5] How much zinc is to be replaced by copper? Copper has a much larger thermal absorption cross section than zinc, and a finite resonance integral while zinc has no entry under resonance integral. What is the magnitude of the effect of this substitution?

ANSWER:

In the selected experiments, zinc is present as an impurity in the aluminum alloys. Among the different aluminum alloys used in the analyzed experiments, 6061 aluminum has the largest zinc content. The ASTM Standard for this aluminum alloy specifies a maximum limit on zinc impurity of 0.25wt%. However, nominal values are lower. The other aluminum alloy zinc contents are distributed around 0.05wt%. To conservatively quantify the effect of the substitution, some configurations are evaluated by removing the zinc content of the aluminum alloys. The substitution of the nominal amount of zinc by copper, compared with removing zinc in the calculations, has an insignificant effect on the Keff, as shown by the sample calculations in Table 9.1.1.1.

Table 9.1.1.1 Effect of the Replacement of Zn by Cu

Zn (wt%)
0.125
0.25
0.125
0.03
0.15
0.125

Note: the Zn content shown in the last column corresponds to the aluminium alloy with the highest substituted Zn content. And the Zn contents in all the other aluminium alloys were also substituted.

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.

RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION

2/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO.155-1442 REVISION 0**

SRP SECTION: **09.01.01 - CRITICALITY SAFETY OF FRESH AND SPENT FUEL STORAGE AND HANDLING**

APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **1/14/2009**

QUESTION NO. : 09.01.01-2

[Page 5] Why are the analyses in this report limited to ENDF/B-V? Other evaluations are either more modern, or include the nuclides of interest (i.e. zinc). Are there any plans to switch to the use of newer nuclear data libraries, or, at a minimum, quantitatively determine the effect for key selected configurations?

ANSWER:

MHI performed the benchmark evaluation of all 120 cases described in MUAP-07020 (R0) using three nuclear data libraries as follows: ENDF/B-V, ENDF/B-VI Release 2 and ENDF/B-VI Release 6.

Among these libraries, the difference in the mean k_{eff} and bias uncertainty is very small (see Table 9.1.1.2) and since the ENDF/B-V cross section set maximizes the weighted mean multiplication factor ($\overline{k_{eff}}$), it was selected.

Therefore, MHI does not plan to switch libraries.

Table 9.1.1.2 Effect of ENDF Evaluation on Bias and Mean Bias Uncertainty

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: **1/14/2009**

QUESTION NO. : 09.01.01-3

[Page 6] The USL is represented by the following formula (based on Reference 5):
USL = $1 - \Delta k + \beta - \Delta\beta$, where $\Delta\beta$ is the statistical uncertainty.
Why is $\Delta\beta$ only subtracted and not defined as an uncertainty interval (meaning $\pm\Delta\beta$)?

ANSWER:

Since the statistical uncertainty $\Delta\beta$ is always taken as a positive value, conservatively, $\Delta\beta$ is only subtracted. This conservatism is the same as the one applied to the β, which is set to zero when it is positive to avoid relaxation in the USL requirement.

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: **1/14/2009**

QUESTION NO. : 09.01.01-4

[Page 10] What is the definition of the "one sided tolerance factor U"?

ANSWER:

For a normal random variable X with known mean μ and known standard deviation σ, it is possible to say that exactly a proportion P of the normal population is above $\mu - K_p \cdot \sigma$, where K_p is the inverse normal probability distribution.

In most cases, however, μ and σ are not known and it is necessary to extract from a sample. Then, a tolerance limit of the form $\bar{x} - U \cdot s$ may be used; where $\bar{x}$ is an estimate of μ, and s is an estimate of σ. However, since $\bar{x}$ and s are random variables, the tolerance limit statement can only be made with a given probability attached.

The problem then reduces to find U, such that the probability is γ that at least a proportion P of the population is above $\bar{x} - U \cdot s$. Therefore, the "one sided tolerance factor U" is defined such that "at least a proportion P of the population of $\bar{x}$ is greater than $\bar{x} - U \cdot s$ with confidence γ". Values of U make the following probability statement true:

$$\Pr\{\Pr(X \geq \bar{x} - U \cdot s) \leq P\} = \gamma$$

The quantity U is defined equivalently in terms of the non-central t-distribution, as follows:

$$\Pr\{\text{non-central } t \leq U\sqrt{n} \mid K_p\sqrt{n}\} = \gamma$$

where n is the sample size.

This explanation is based on Reference [10] of the MHI technical report MUAP-07020 (R0).

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.

RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION

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APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **1/14/2009**

QUESTION NO. : 09.01.01-5

All experiments described in section 5 refer to fresh LEU fuel. However, the spent fuel contains a significant amount of plutonium, which causes a decrease in the reactivity worth of control materials containing boron-10. What is the rationale for not including plutonium-containing experiments in the set of validating experiments? What assurance is there that the procedure described in the document produces a valid (or conservative) estimate of the uncertainty to ensure that the required level of sub-criticality is achieved for fuel containing plutonium (and other actinides)?

ANSWER:

The present fuel storage rack design does not take credit for the fuel burn-up. It is based on the fresh fuel assumption, using the maximum allowable uranium fuel enrichment of 5wt% and without taking credit for any burnable absorbers, like gadolinium.
For 5wt% enriched uranium fuel assemblies, the decrease in reactivity with burn-up due to the uranium depletion and fission products buildup is greater than the increase in reactivity effect of plutonium, which is created with fuel burn-up. This reactivity decrease of the fuel assemblies with burn-up is greater than the decrease in the reactivity worth of control materials containing boron-10.

Therefore, LEU fuel experiments are chosen and are conservative. Of course, in the case that credit for fuel burn-up is introduced, MOX experiments, which would include the effects of plutonium creation, can be considered.

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: **1/14/2009**

QUESTION NO. : 09.01.01-6

[Section 5] Are the poison loadings and plate thicknesses in the separator plate experiments considered for validation prototypic (or bounding) of those in the fuel racks and other configurations to which this methodology will be applied?

ANSWER:

The poison loadings and plate thicknesses in the separator plate experiments are not considered as key critical system parameters as shown in Table 4-1 of MHI technical report MUAP-07020 (R0). However, in the selection of the experiments, the candidate materials mentioned in sections 9.1.1 and 9.1.2 (stainless steel, borated stainless steel or proven boron absorbers such as Boral and Metamic) of the DCD are considered. Tables 5.3, 5.4, and 5.5 of the technical report MUAP-07020 (R0) show the poison loadings and plate thickness of the critical experiments. A plot of the calculated k_{eff} for each critical experiment as a function of the areal B-10 loading (a combination of the thickness and loading) is provided below as Figure 9.1.1.1 of response to question No. 09.01.01-8. As can be seen in the figure, there is not a significant trend as a function of areal density.

SS for the new fuel rack and B-SS for the spent fuel rack are used as representative materials to show the design in MHI technical report MUAP-07032-P (R0). The SS and B-SS thicknesses and the boron content in the B-SS plates of the selected experiments cover the ranges of those presented for the new and spent fuel racks by the MHI report. The B-SS B-10 areal density is 0.0054 grams of B-10/cm^2. As can be seen using Figure 9.1.1.1 of response to question No. 09.01.01-8, this areal density is in the range of the critical experiments used.

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: **09.01.01 - CRITICALITY SAFETY OF FRESH AND SPENT FUEL STORAGE AND HANDLING**

APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **1/14/2009**

QUESTION NO. : 09.01.01-7

[Section 6] Provide details concerning the MCNP calculations including the number of batches, number of histories-per-batch, and whether the calculations were single runs or restarts to improve prediction of fundamental mode, etc. Are the calculated results symmetric when they should be? Provide two sample MCNP input decks. The first input deck should describe one of the validating experiments that includes a poisonous plate, and the second deck should describe a proposed storage rack design.

ANSWER:

The criticality source card in the MCNP inputs were set to accumulate a total of around 4 million neutron histories for each run, as follows;

Number of neutron histories per batch (NSRCK in KCODE) = [ ]
Number of batches per run (KCT in KCODE) = [ ]
Number of skipped cycles (IKZ in KCODE) = [ ]

All the experimental results were obtained by single runs without restart, since the results converged.

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.

RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION

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APPLICATION SECTION: **9.1.1**

DATE OF RAI ISSUE: **1/14/2009**

QUESTION NO. : 09.01.01-8

[Section 7] Why were poison loading and plate thickness not considered as "correlated parameters" for the separator plate configurations?

ANSWER:

In our experience, there have not been observed trends on the B-10 loading and thickness of the separator plates, normally put together as B-10 areal density. Therefore, if the range of experiments covers the intended application, considering B-10 areal density as a correlated parameter is not required. However, analysis has been performed to determine whether the variation in the B-10 areal density creates a significant trend in the calculated k_{eff} of the critical experiments. Figure 9.1.1.1 shows a plot of the calculated k_{eff} as a function of the areal density. The result of the regression analysis shows that the correlation factor, r^2, is[ ], which allows the conclusion that a real trend does not exist.

Figure 9.1.1.1 k_{eff} vs. B-10 Loading (Separator Plate Experiments)

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.