MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

August 11, 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-09417

Subject: **MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR" on 06/11/2009**

Reference: 1) "REQUEST FOR ADDITIONAL INFORMATION ON TOPICAL REPORT MUAP-07013-P, 'SMALL BREAK LOCA METHODOLOGY FOR US-APWR'," dated June 11, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") an official document entitled 'MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR" on 06/11/2009'. In the enclosed document, MHI provides the 11 (twenty) out of 31 (thirty-one) items requested in Reference 1. The remaining responses to the RAI in Reference 1 were transmitted to the NRC by separate correspondence, on July 10, 2009 (30 days after the issuance of the formal RAI), as agreed by NRC and MHI.

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 in this package (Enclosure 3). Any proprietary information that is written inside a bracket in the proprietary-version is replaced by the designation "[ ]" without any text, in the non-proprietary-version.

This letter includes a copy of proprietary version (Enclosure 2), a copy of non-proprietary version (Enclosure 3), proprietary information and data recorded on CD (Enclosure 4), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the bases of MHI request that all materials designated as "Proprietary" in Enclosure 2 and all information and data recorded on CD of Enclosure 4 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 this submittal. His contact information is provided below.

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NRO

Sincerely,

Y. Ogata

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

Enclosures:

1. Affidavit of Yoshiki Ogata

2. MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR" on 06/11/2009 (proprietary)

3. MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR" on 06/11/2009 (non-proprietary)

4. CD: "M-RELAP5 User Manuals and Corrected Input Decks for ORNL/THTF Calculations"

The files contained in this CD are listed in Attachment 1.

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

Contact Information
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ENCLOSURE 1

Docket No.52-021
MHI Ref: UAP-HF-09417

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, being duly sworn according to law, depose and 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 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 "MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (R0) 'Small Break LOCA Methodology for US-APWR' on 06/11/2009" and have determined that portions of the report 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 technical report indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4). Similarly, all data recorded on the enclosed CD should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information in the report identified as proprietary by MHI 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 codes and files developed by MHI for the fuel of the US-APWR and also contains information provided to MHI under license from the Japanese Government. These codes and files were developed at significant cost to MHI, since they required the performance of detailed calculations, analyses, and testing extending over several years. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI and the Japanese Government.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of supporting the NRC staff's review of MHI's Application for certification of its US-APWR Standard Plant Design.

6. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without the costs or risks associated with the design of new fuel systems and components. Disclosure of the information identified as

proprietary would therefore have negative impacts on the competitive position of MHI in the U.S. nuclear plant market.

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 11th day of August, 2009.

Y. Ogata

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

ENCLOSURE 3

UAP-HF-09417

MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR" on 06/11/2009

August 2009
(Non-Proprietary)

REQUEST 4-16
(Related RAI 4-11)

PIRT tables provide ranking of all phenomena as they impact the figure of merit. However, it is not clear how high and medium rank phenomena are treated. Why are some high ranked phenomena (Table 4.3.2-2) not validated (Table 4.4.2-1)? Are medium ranked phenomena validated? Are high and medium ranked phenomena, not covered by Appendix K, modeled with best estimate or conservative models in the SBLOCA analyses?

RESPONSE

On how high and medium rank phenomena are treated and validated
Medium ranked phenomena are not assessed with high level of detail. Highly ranked phenomena are investigated through separate effects assessments, but medium and low ranked phenomena are assessed indirectly during integral assessments. Thus, from a practical point of view, there is not much difference between medium and low rankings.

On why some high ranked phenomena (Table 4.3.2-2) not validated (Table 4.4.2-1)
Some high ranked phenomena in Table 4.3.2-2 do not appear in Table 4.4.2.1. These are conservatively treated for the safety analysis as follows, and are not addressed in the code validation plan.

Decay heat – Conservative Appendix K model is applied with a multiplication factor of 1.2.

Local power, 3-D power distribution – Conservative input or assumption is applied (i.e. worst case peaking factors)

Critical flow – Appendix K model is applied. Verification was performed to determine that the implementation was correct. Break spectrum analysis was performed to determine worst case break size and location (Ref. 1).

Break flow enthalpy – Sensitivity calculations were performed to determine the worst break orientation, top, bottom, and side connections (Ref. 1). The break orientation influences the two-phase flow behavior to be discharged from the break that eventually affects the energy to be discharged through the break.

DVI/SI water flow rate – Flow rate and temperature of the safety injection are treated by conservative input and assumption to obtain limiting results.

Reference:
1. Mitsubishi Heavy Industries, Ltd., Small Break LOCA Sensitivity Analyses for US-APWR, Technical Report, MUAP-07025-P (R0).

REQUEST 4-17
(Related RAI 4-12)

Section 4.4.2 refers to confirmation plan for high ranking phenomena. What are the acceptance criteria for confirming the model of a given phenomenon? How is it established that the code model will accurately represent the phenomenon (e.g., percentage difference)? How is it determined that the code prediction is conservative? How is the uncertainty of measurement accounted for? Is there any sensitivity study?

RESPONSE

On the acceptance criteria for confirming the model of a given phenomenon, the response to RAI 4-12 (Ref. 1) already describes the process in general. The objectives are (1) to confirm that the models do not result in significantly non-conservative predictions, and (2) to verify that the Appendix K models provide sufficient conservatism in the safety analysis.

The RELAP5-3D, which is the based code for the M-RELAP5 that incorporates the Appendix-K Evaluation Model, has been verified of being capable to capture all phenomena during a small-break LOCA postulated to occur in a conventional PWR. All important phenomena and phases during a SBLOCA transient in the US-APWR are identical to that of conventional PWR. All the high-ranking phenomena are identified in the PIRT and are validated by both separate and integral effect tests. The results of M-RELAP5 prediction showed conservatisms in certain phenomena and realistic for other certain phenomena.

The thermal-hydraulic models in M-RELAP5 were initially developed for best-estimate method. Therefore, some discrepancies and deviation are obviously observed, that were caused by model uncertainty. The implementation of Appendix K evaluation models result in the accommodation of all these deviation. In other words, the conservative Appendix K evaluation model well bound the deviation.

On the sufficiency of conservativeness of the Appendix-K evaluation models, the decay heat model that multiplied with a factor of 1.2 demonstrates the sufficiency of the models. In this context, the M-RELAP5 has also been validated using the THTF Uncovered-Bundle Heat Transfer Test data. Figures 8.1.2-31 and 32 in the topical report MUAP-07013-P (R0) show the results of a sensitivity study in which the rod power is raised 1.2 times of the nominal power to conform to the Appendix K requirement that affect local power. The results show that by applying the Appendix K model yields significant conservativeness in the mixture level and rod surface temperature predictions. A similar investigation has also been done in addressing the code applicability to SBLOCAs by using the integral test data obtained in the ROSA/LSTF test facility (refer to Figures 8.2.1-53 to 60 of MUAP-07013-P (R0)).

Reference:

1. Mitsubishi Heavy Industry, Ltd., MHI's Partial Responses to NRC's Requests for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR", UAP-HF-09002, January 16, 2009.

REQUEST 6-4
(Related RAI 6-1)

Provide documentation of the changes made to RELAP5-3D that created M-RELAP5. The level of documentation detail should be the same as the RELAP5-3D manual. Either the changes can be added to the RELAP5-3D documentation and a complete code manual provided, or an Addendum can be issued. The documentation needs to identify any RELAP5-3D features that are not relevant for M-RELAP5.

RESPONSE
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REQUEST 7-16
(Related RAI 7-2)

Comparisons to FLECHT heat transfer correlation for reflood rates greater than 1" per second. MHI previously stated that this did not apply to SBLOCA based on NOTRUMP SER, but the APWR limiting break size is much larger than typical PWRs (3-4 inches).

Please provide a discussion addressing the larger limiting break size for the APWR which justifies the MHI position of not comparing to FLECHT data.

RESPONSE
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REQUEST 7-20
(Related RAI 7-8)

M-RELAP5 has implemented its own model for the transition from subcooled single-phase critical flow to two-phase critical flow. From the original response to RAI 7-8 it appears that MHI is taking credit for a lower critical flow rate when vapor phase exists with subcooled liquid in the volume upstream of the break. Also a special numerical scheme was implemented to smooth out the prediction of critical flow when the transition occurs.

Provide validation analyses against critical flow tests that span conditions of subcooled liquid with vapor and also transition from single-phase liquid to two-phase critical flow.

Is the under-relaxation method part of the Appendix K modification or part of the M-RELAP5 base code (i.e. the under-relaxation method is in operation even if none of the Appendix K model is activated)?

RESPONSE
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REQUEST 7-22
(Related RAI 7-10)
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RESPONSE
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REQUEST 8-4

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RESPONSE

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REQUEST 8-5

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RESPONSE

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REQUEST 8.1-4
(Related RAI 8.1-2)

The timings of PCT in the RAI response of 8.1-2 cover 7.5-inch and 1 ft^2 break.

Discuss whether the LHGR of the tests cover the range of PCT timing of other break sizes.

Also discuss if the mass flux of these simulations cover the range of mass flux of entire SBLOCA spectrum of break sizes.

RESPONSE

In discussing whether the linear heat generation rate (LHGR) of the tests covers the range of PCT timing during US-APWR SBLOCAs, the break spectrum being addressed is reasonably extended from 2-in to 1.0-ft^2 break at the cold-leg. The PCT occurrence timing after the reactor SCRAM is listed in **Table RAI 8.1-4.1**. Significant fuel cladding heat-up are shown during the loop seal clearance phase from 6 to 8-in break cases, while the heat-up occurs during the boil-off and recovery phase from 12-in to 1.0-ft^2 break cases. No significant heat-up appears for the other break sizes in US-APWR.

The PCT timing and the corresponding LHGR data ranges in US-APWR SBLOCAs are compared with the experimental test conditions, ROSA/LSTF and ORNL/THTF void profile, uncovered-bundle heat transfer, and high-pressure reflood tests which are used in M-RELAP5 code assessment (see MHI response to RAI 8.1-2 (Ref. 1)), in **Figure RAI-8.1-4.1**. The PCT occurs from 100 to 180 seconds after the reactor SCRAM for US-APWR, and the test data cover the range from 15 seconds after the SCRAM when the ANS-1971 decay heat power is assumed. Even if the 20% conservatism is taken into account for the decay heat, the test data satisfy the PCT timing range expected in US-APWR SBLOCAs as shown in Figure RAI-8.1.4-1.

The core inlet mass flux condition expected in US-APWR SBLOCAs is compared with the experimental test range. From the viewpoint of the impact on PCT, the core inlet mass flux plays an important role from the loop seal clearance to core recovery periods in US-APWR SBLOCAs. Therefore, the corresponding data in the ORNL/THTF tests are compared with the US-APWR SBLOCA flow range.

The mass flux data in the experiments are listed in **Table RAI-8.1.4-2**. The plant core flow range are shown in **Table RAI-8.1.4-3**, each of which is obtained by averaging the core inlet flow from the beginning of the loop seal clearance period to the end of core recovery period. These data are compared in **Figure RAI-8.1.4-2**, indicating that the test data sufficiently cover the range expected in US-APWR SBLOCAs.

Reference:
1. Mitsubishi Heavy Industry, Ltd., MHI's Partial Responses to NRC's Requests for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR", UAP-HF-09002, January 16, 2009.

Table RAI-8.1-4.1 PCT Time after Reactor SCRAM

Scenario	PCT Duration	PCT Time after SCRAM (sec)
CLB 2.0 in	-	-
CLB 4.0 in	-	-
CLB 6.0 in	LSC	[ ]
CLB 7.5 in	LSC	[ ]
CLB 8.0 in	LSC	[ ]
CLB 10 in	-	-
CLB 12 in	BO	[ ]
CLB 1.0 ft^2	BO	[ ]

LSC: Loop Seal Clearance BO : Boil-off/Core Recovery

Table RAI-8.1-4.2 Mass Flux Data in ORNL/THTF and FLECHT-SEASET Tests

Test	Case	Flooding Mass Flux (lbm/ft^2-s)	Remarks
ORNL/THTF	3.09.10J	12.93	Uncovery Test
	3.09.10K	2.22	Uncovery Test
	3.09.10M	13.38	Uncovery Test
	3.09.10N	4.33	Uncovery Test
	3.09.10AA	21.15	Void Profile Test
	3.09.10BB	9.44	Void Profile Test
	3.09.10CC	7.22	Void Profile Test
	3.09.10DD	19.82	Void Profile Test
	3.09.10EE	11.00	Void Profile Test
	3.09.10FF	4.83	Void Profile Test
	3.09.10P	16.55	High-Pressure Reflood Test
	3.09.10Q	10.74	High-Pressure Reflood Test

Table RAI-8.1-4.3 Core Inlet Mass Flux Condition in US-APWR SBLOCAs

Scenario	PCT Duration	Core Inlet Mass Flux (lbm/ft^2-s)
CLB 2.0 in	-	-
CLB 4.0 in	-	[ ]
CLB 6.0 in	LSC	[ ]
CLB 7.5 in	LSC	[ ]
CLB 8.0 in	LSC	[ ]
CLB 10 in	-	[ ]
CLB 12 in	BO	[ ]
CLB 1.0 ft^2	BO	[ ]

LSC: Loop Seal Clearance BO: Boil-off/Recovery

Figure RAI-8.1-4.1 Comparison of LHGR Range between Experimental Tests and US-APWR SBLOCAs

Figure RAI-8.1-4.2 Comparison of Mass Flux Range between Experimental Tests and US-APWR SBLOCAs

REQUEST 8.1-5
(Related RAI 8.1-3)

Sensitivity study in the nodalization of the plant model is not a substitute for sensitivity study for the test simulation.

Demonstrate that conclusions derived from the simulation do not depend on the nodalization of the test facilities (especially for the nodalization of the ROSA/LSTF cross-over legs, which are substantially different from the plant model).

RESPONSE
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REQUEST 8.1.4-8
(Related RAI 8.1.4-4)
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RESPONSE
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Appendix A

Additional Information in Response to REQUEST 8.1-5

MITSUBISHI HEAVY INDUSTRY, LTD.

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ATTACHMENT 1
FILES Contained in CD

CD: "M-RELAP5 User Manuals and Corrected Input Decks for ORNL/THTF Calculations"
- Proprietary information

Contents of CD

File Name	Size	Sensitivity Level
• THTF_Corrected_Input		
- thtf-3_09_10aa-tp.i	20KB	Proprietary
- thtf-3_09_10bb-tp.i	20KB	Proprietary
- thtf-3_09_10cc-tp.i	20KB	Proprietary
- thtf-3_09_10dd-tp.i	20KB	Proprietary
- thtf-3_09_10ee-tp.i	20KB	Proprietary
- thtf-3_09_10ff-tp.i	20KB	Proprietary
- thtf-3_09_10j-tp.i	20KB	Proprietary
- thtf-3_09_10k-tp.i	20KB	Proprietary
- thtf-3_09_10m-tp.i	20KB	Proprietary
- thtf-3_09_10n-tp.i	20KB	Proprietary
- thtf-3_09_10p-tp.i	15KB	Proprietary
- thtf-3_09_10q-tp.i	15KB	Proprietary
• M-RELAP5_Manual		
- MR5_Vol_1_Supplement_r8.pdf	583KB	Proprietary