MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

February 5, 2010

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-10039

Subject: MHI's 1st Response to US-APWR DCD RAI No. 514-4040 Revision 2

Reference: 1) "REQUEST FOR ADDITIONAL INFORMATION 514-4040 REVISION 2" dated December 17, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") an official document entitled 'MHI's 1st Response to US-APWR DCD RAI No. 514-4040 Revision 2'. In the enclosed document, MHI provides the 18 (eighteen) out of 21 (twenty-one) items requested in Reference 1. The remaining responses to the RAI in Reference 1 will be transmitted to the NRC by separate correspondence on February 15, 2010 (60 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), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the bases of MHI request 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 this submittal. His contact information is provided below.

Sincerely,

Y. Ogata

Yoshiki Ogata

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

DD81
NRO

Enclosures:

1. Affidavit of Yoshiki Ogata
2. MHI's 1st Response to US-APWR DCD RAI No. 514-4040 Revision 2 (Proprietary)
3. MHI's 1st Response to US-APWR DCD RAI No. 514-4040 Revision 2 (Non-Proprietary)

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

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ENCLOSURE 1

Docket No.52-021
MHI Ref: UAP-HF-10039

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 1st Response to US-APWR DCD RAI No. 514-4040 Revision 2" 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).

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 5th day of February, 2010.

Y. Ogata

Yoshiki Ogata

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

ENCLOSURE 3

UAP-HF-10039

MHI's 1st Response to US-APWR DCD RAI No. 514-4040 Revision 2

February 2010
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/5/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 514-4040 REVISION 2**
SRP SECTION:	**15.06.05 – LOSS OF COOLANT ACCIDENTS RESULTING FROM SPECTRUM OF POSTULATED PIPING BREAKS WITHIN THE REACTOR COOLANT PRESSURE BOUNDARY**
APPLICATION SECTION:	**DCD CHAPTER 15.6.5. SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-58

Section 2.2 of MUAP-07025-P categorizes Appendix K Requirement # 4, Initial Stored Energy in Fuel, as Category 2 "Inputs Address this Requirement". However, Section 7.1.2 of MUAP-07013-P states that an annular pellet-to-clad gap heat transfer model derived from the FINE fuel rod design computer code has been implemented in M-RELAP5. The staff also notes that MUAP-07013-P categorizes Appendix K Requirement # 4 as Category 1 "Code Models".

Revise or explain the categorization of Appendix K Requirement # 4, Initial Stored Energy in Fuel, in Section 2.2 of MUAP-07025-P.

ANSWER:

Two approaches are required to conform to Appendix K for Requirement #4. The first approach is to install the gap conductance model consistent with the fuel design code and the second approach is to provide appropriate input. To satisfy the requirement, a gap conductance model consistent with the fuel design code was installed in the M-RELAP5 and appropriate input to that model was provided. Thus, a combination of approaches was used to satisfy the requirement.

Therefore, Requirement #4 belongs to not only Category 1 but also Category 3 in MUAP-07013-P. And also this requirement belongs to not only Category 2 but also Category 1 in MUAP-07025-P. The definition of the Category is different between MUAP-07013-P and MUAP-07025-P. MHI will correct MUAP-07013-P and MUAP-07025-P.

As for the Appendix K Requirement #4 on the Initial Stored Energy in the Fuel, the steady-state temperature distribution in the fuel before the break was applied for the burn-up that yields the highest fuel stored energy. To accomplish this, the thermal conductivity of the UO_2 was evaluated as a function of burn-up, and the thermal conductance of the gap between the pellet and the cladding was evaluated as a function of burn-up, taking into consideration the fuel densification, the cladding creep down, and the composition and pressure of the gases within the fuel rod.

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.

2/5/2010

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DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-59

Appendix K Requirement # 27, Reflood Rate, is categorized in MUAP-07025-P as Category 1 "Code Models". In MUAP-07013-P, however, Appendix K Requirement # 27, Reflood Rate, is categorized as being addressed with code inputs.

Explain the difference in the categorization of Appendix K Requirement # 27, Reflood Rate, as presented in MUAP-07025-P and MUAP-07013-P. Describe any new models implemented in M-RELAP5 that pertain to the reflood rate calculation.

ANSWER:

The reflood rate is calculated considering the thermal and hydraulic characteristics of the core and the reactor systems in M-RELAP5 and the thermal and hydraulic model contained in RELAP5-3D is used as it is. Then, a validation study is required for Requirement # 27 to conform to Appendix K. Therefore, Requirement #27 should belong to Category 2 rather than Category 3 in the MUAP-07013-P. MHI will correct MUAP-07013-P. The reflood phenomena including the reflood rate is validated against the ROSA-IV/LSTF LOCA test.

The categorization of Appendix K Requirement #27 in the MUAP-07025-P is the correct one because the definition of the Category is different from that in MUAP-07013-P.

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:	**12/17/2009**

QUESTION NO.: 15.06.05-60

MUAP-07025-P Section 2.2, Table 2-1 states that Appendix K Requirement # 29, Refill/Reflood Heat Transfer, is not applicable to SBLOCA. However, during SBLOCA the water level in the core may drop below TAF during the loop seal clearance and boil-off phases of a SBLOCA. PIRT Phenomenon 11 ranks Rewet Heat Transfer as HIGH for the loop seal clearance, boil-off, and recovery phases of a SBLOCA. This statement may require modification based on responses to MUAP-07013-P (R0) RAI responses.

ANSWER:

The refill/reflood heat transfer is calculated using the post-CHF heat transfer model in M-RELAP5 rather than the Reflood model in M-RELAP5 or the FLECHT heat transfer correlations when reflood rates are 1-inch/s or higher. Then, a validation study is required for Requirement #29 to conform to Appendix K. The reflood heat transfer calculation is validated against the ORNL/THTF High-Pressure Reflood test.

As the reflood rates generated from the injections of accumulator and SI pumps are gather than 1 inch/s for the US-APWR SBLOCA analysis, the requirement for low flooding rates is not applied to the US-APWR SBLOCA analysis. The reflood velocities under US-APWR SBLOCAs are given in MHI's response to REQUEST 7-16 on M-RELAP5 Topical Report MUAP-07013-P (Ref.1).

Therefore, Requirement #29 should belong to Category 2 as same as Requirement #21 for the post-CHF heat transfer correlation in MUAP-07013-P. And also, it should belong to Category 1 in MUAP-07025-P. MHI will correct MUAP-07013-P and MUAP-07025-P.

Reference:

1. Mitsubishi Heavy Industries, Ltd., 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, UAP-HF-09417, Autust 2009.

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:	**12/17/2009**

QUESTION NO.: 15.06.05-62

PIRT Phenomena 37 Water Holdup in SG Inlet Plenum and 38 Water Hold-up in U-Tube Uphill Side highlight the importance of countercurrent flow limitation (CCFL) characteristics in the SG tubes, SG inlet plenum, and hot leg piping during loop seal clearance phase of SBLOCA. MUAP-07013-P provides comparisons of M-RELAP5 to UPTF hot leg tests and the Dukler air-water flooding tests and concludes that the M-RELAP5 model results are acceptable.

Considering the importance of CCFL relative to core cooling during the loop seal clearance phase of SBLOCA, evaluate the variability of PCT with CCFL model coefficients (both for the hot leg and the SG tubes) and justify the values used in the SBLOCA evaluation model. Responses to earlier RAIs may cover this topic.

ANSWER:

Sensitivity calculations in terms of the CCFL at the SG inlet plenum and in the SG U-tubes are given in MHI's response to RAI CA-1 on the M-RELAP5 topical report MUAP-07013-P (Ref. 1).

[

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The MHI response to RAI CA-1 concluded that the loop seal PCT is well suppressed by the enhanced capacity of the high head injection system (HHIS) in the US-APWR design.

Reference:

1. Mitsubishi Heavy Industries, Ltd., 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 09/08/2009, UAP-HF-09512, November 2009.

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:	**12/17/2009**

QUESTION NO.: 15.06.05-63

MUAP-07025-P section 4.1.8 states that the accumulator nominal water volume is 2150 ft^3 (excluding the ineffective water) whereas FSAR Section 6.3.2.2.2 and FSAR Table 6.3-5 give the accumulator water volume as 2126 ft^3 excluding the ineffective volume. Explain the apparent discrepancy in the effective accumulator water volume cited in MUAP-07025-P section 4.1.8 and FSAR Section 6.3. Identify the accumulator water volume utilized in the SBLOCA evaluation model.

ANSWER:

The accumulator water volume used for US-APWR SBLOCAs analyses is explained in MHI's response to QUESTION 06.03-81 in RAI No. 407-3082 Revision 1 (Ref.1).

As shown in Table 15.6.5-1 of the US-APWR DCD (Ref.2), the accumulator water volume without the dead volume ranges from 2126 to 2179 ft^3. The nominal (reference) data of 2152 ft^3 is used for the US-APWR SBLOCA analyses.

Table 6.3-5 in Reference 3 lists the lowest value for the accumulator water volume excluding the dead volume. The accumulator water volume data used for the SBLOCA analyses in Table 15.6.5-2 has been correctly updated from 2150 ft^3 to 2152 ft^3 in Revision 2 of the US-APWR DCD (Ref.2), as explained in Reference 1.

References:

1. Mitsubishi Heavy Industries, Ltd., MHI's Response to US-APWR DCD RAI No.407-3082 Revision 1, UAP-HF-09419, August 2009.
2. Mitsubishi Heavy Industries, Ltd., Design Control Document for the US-APWR, Chapter 15 Transient and Accident Analyses, MUAP-DC015, Revision 2, November 2009.
3. Mitsubishi Heavy Industries, Ltd., Design Control Document for the US-APWR, Chapter 6 Engineered Safety Features, MUAP-DC006, Revision 2, November 2009.

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:	**12/17/2009**

QUESTION NO.: 15.06.05-64

Section 5.1.1 (1) of MUAP-07025-P states that after about 10 minutes following the 2-inch cold-leg break, the collapsed downcomer level abruptly drops, as also shown in Figure 5.1.1.a-6.

Explain this rapid change in downcomer level.

ANSWER:

The drop of the collapsed downcomer level coincides with a decrease of liquid mass in the vessel. Expanded views of the downcomer (DC), upper plenum (UP), and guide tube (GT) collapsed liquid levels are shown in Figure RAI-15.6.5-64.1. Temporal changes for the collapsed levels in the downcomer and guide tube are similar around [ ], where the liquid level in the guide tube decreases at about the same rate as in the downcomer. The decrease in these liquid levels is caused by the inventory loss out the break. The levels are nearly constant after [ ] because the flow from the SI pumps approximately balances the break flow.

From [ ], there appear oscillatory behaviors in liquid levels for the upper plenum and guide tube regions. Sources of the oscillatory behavior are explained in MHI's response to QUESTION 15.06.05-37 (Ref.1).

Reference:

1. Mitsubishi Heavy Industries, Ltd., MHI's Response to US-APWR DCD RAI No. 352-2369 Revision 1, UAP-HF-09384, July 2009.

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.

Figure RAI-15.6.5-64.1 Liquid Level Histories in Downcomer, Upper Plenum and Guide Tube

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DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-66

Section 5.1.1 of MUAP-07025-P provides the results of the break location sensitivity study. Provide the following additional information on the results of the 1-ft^2 cold-leg bottom break presented in Section 5.1.1:

Explain the relationships among the three collapsed liquid levels shown in Figure 5.1.1.a-16 and the reported core upper region uncovery occurrence at 103 seconds given in Table 5.1.1.a-3 for the 1-ft^2 cold leg SBLOCA. Explain the statement contained in Section 5.1.1 (2) that the "...figure also implies that a remarkable core uncovery occurs ...".

ANSWER:

Rapid depressurization and coolant loss following the break initiation cause flashing and voiding of coolant in the core and upper plenum regions, which decreases their collapsed liquid levels. During the blowdown phase, however, the surface of fuel rod cladding is covered by the two-phase mixture coolant in all locations, implying that the two-phase mixture level remains above the top of the core. With the continued coolant loss from the RCS, the collapsed liquid levels decrease further in the core and upper plenum regions and the liquid coolant is completely depleted in the upper plenum around 100 seconds after the break initiation. The mixture level drops below the top of the core at 103 seconds, and fuel cladding starts heating up in the upper core region. At about 120 seconds, the safety coolant injection begins to reflood the core, and the collapsed liquid level starts increasing. The mixture level reaches the top of the average assembly in the core at about 180 s. Therefore, the collapsed liquid level in the upper plenum starts increasing despite the fact that the collapsed liquid level in the core is below the top of the core. Although the collapsed liquid level in the hot assembly behaves the same as in the other assemblies, the heat-up continues at the hot rod in the hot assembly until 326 seconds after the break initiation.

The phrase "remarkable core uncovery" applies to the 1-ft^2 cold leg break case relative to the other break scenarios because a much larger decrease in core collapsed liquid level occurs. This indicates that the mixture level is also substantially lower and that the severest core uncovery occurs during the 1-ft^2 cold leg break case.

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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QUESTION NO.: 15.06.05-67

Section 5.1.3 summarizes the results of the steam phase pressurizer break and states that there is a "slight core uncovery of about 4-ft" for the pressurizer steam phase break; however, Table 5.1.3-1 for the pressurizer steam phase break states that core uncovery does not occur.

Explain the apparent discrepancy between the Section 5.1.3 text and associated Table 5.1.3-1.

ANSWER:

The explanation for Figure 5.1.3-7 in Section 5.1.3 is incorrect. Core uncovery does not occur during the pressurizer steam phase break. The 4-ft uncovery refers to the decrease in collapsed liquid level in the core. However, the mixture level remains above the top of the core as illustrated by the collapsed level in the upper plenum as shown in Figure 5.1-3-7. Figure 5.1.3-8 (PCT at all elevations for hot rod in hot assembly) shows that no heat-up occurs during the transient. The fuel cladding temperature decreases after the break and gets lower than the initial temperature, confirming that the core remains covered throughout the transient.

The information in Table 5.1.3-1 is correct. MHI will modify the sentences in Section 5.1.3.

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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QUESTION NO.: 15.06.05-68

Section 5.2 of MUAP-07025-P provides the break spectrum analysis for the cold-leg break SBLOCA. The break spectrum analysis is performed assuming LOOP concurrent with reactor trip. The sensitivity of the cold-leg SBLOCA to the availability of off-site power (non-LOOP) is provided in Section 5.6.2 for only the limiting loop-seal PCT and boil-off PCT cases, i.e., the 7 ½-inch and 1-ft^2 top cold-leg break cases, respectively.

The availability of off-site power affects RCP trip time and ECC equipment response in a manner that could potentially affect PCT. Provide justification for analyzing only the limiting loop-seal and boil-off PCT cold-leg SBLOCA cases with off-site power available.

ANSWER:

When LOOP (loss of offsite power) is not assumed in the analyses, the RCPs continue to operate till any automatic or manual action to trip RCPs, which causes a larger flow through the core compared to the case assuming LOOP. This tends to prevent core dryout and uncovery. In addition, the pumped SI (safety injection) starts operation when the ECCS signal is generated when offsite power is available. This also contributes to the prevention of core dryout and uncovery.

However, there remains a possibility that the continuous operation of RCPs (the case without assuming LOOP) invokes a severer consequence than the case assuming LOOP, because the forced recirculation carries more coolant to the break location. This concern is described also in Section 6.8 of Reference 1, that is "*early pump trip is not preferable in the case where the high-pressure injection can make up the coolant being lost*" in related to possible SBLOCA scenarios. Therefore, the potential significance of the LOOP assumption could be larger for a case with a smaller break size where the RCS depressurizes slowly and the high-pressure injection is only the system available to replenish the coolant lost from the RCS.

Increase in the coolant mass discharged out the break due to the continuous RCP operation becomes larger only when the RCP operation continues for a longer period, because the increase in the break flowrate due to the continuous RCP operation is quite small. For example, the time of pump trip increased from 12.3 to 29.9 seconds for the 7.5-in cold break case and from 9.9 to 26.3 seconds for the 1-ft^2 cold leg break case when offsite power was assumed to be available. Figures 5.6.2-3 and 5.6.2-16 of MUAP-07025-P show that the increase in discharged liquid due to the continuing RCP operation is negligibly small both for the 7.5-inch and 1-ft^2 cold leg breaks, respectively.

[

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In the 2-inch hot leg break case, which is one of the cases with slowest depressurization, the pressurizer pressure reaches the reactor setpoint and the SI setpoint at 124 and 163 seconds, respectively, as listed in Table 5.1.1.b-1 of MUAP-07025-P. The RCP trips at 127 seconds when LOOP is assumed. [

] On the other hand, the pumped SI starts operating at 281 seconds in the case assuming LOOP, while the SI starts at 163 seconds in the case without assuming LOOP. As explained in MHI's response to RAI CA-1 on the M-RELAP5 topical report (Ref.2), the HHIS (high-head injection system) of the US-APWR is capable to provide the RCS with a sufficient capacity of the safety coolant. Therefore, the earlier start-up of the pumped SI in the case without assuming LOOP is obviously preferable to mitigate the accident consequence, compared with the increase in discharged liquid due to the operated RCPs longer by [ ] than the case assuming LOOP.

In cases with larger break sizes where a faster depressurization is expected, the difference in RCP trip timing between the case assuming LOOP and the case without LOOP becomes smaller than that in the case where a slower depressurization is expected. This mitigates the consequence of accident due to early start-up of the pumped SI as confirmed in Section 5.6.2 of MUAP-07025-P.

In the US-APWR SBLOCA sensitivity studies, therefore, the limiting loop seal and boil-off PCT cases were quantitatively evaluated with respect to the effect of assuming LOOP.

References:

1. USNRC, Compendium of ECCS Research for Realistic LOCA Analysis, NUREG-1230, Revision 4, December 1988.
2. Mitsubishi Heavy Industries, Ltd., MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-0701.3-P (R0) "Small Break LOCA Methodology for US-APWR" on 09/08/2009, UAP-HF-09512, November 2009.

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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QUESTION NO.: 15.06.05-69

MUAP-07025-P Section 5.4.1 part (2), last paragraph, refers to loop-seal phenomena dominating PCT for the 1-ft^2 top cold-leg break. Based on the results shown in the accompanying figures, the PCT appears to occur during the boil-off period, not during loop seal.

Explain the apparent discrepancy in the description and results of PCT occurrence relative to the loop seal or boil-off phase of the transient.

ANSWER:

The statement in Section 5.4.1 part (2), last paraghraph is incorrect and misleading. The revised statement is: "The results show that the noding of the cold leg in the broken loop is adequate to predict the upstream conditions of the break flow when the PCT occurs <u>during the boil-off phase for the 1-ft^2 top-side cold-leg break</u>."

Loop seal clearing phenomena are judged to be insignificant for the 1-ft^2 break case.

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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Mitsubishi Heavy Industries

Docket No. 52-021

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SRP SECTION:	**15.06.05 – LOSS OF COOLANT ACCIDENTS RESULTING FROM SPECTRUM OF POSTULATED PIPING BREAKS WITHIN THE REACTOR COOLANT PRESSURE BOUNDARY**
APPLICATION SECTION:	**DCD CHAPTER 15.6.5. SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-70

The loop noding sensitivity study presented in Section 5.4.2 shows that loop seal clearance is predicted to occur sooner with the finer noding model, resulting in no heatup (PCT).

Provide a comparative description of the loop seal period for both the base case and the sensitivity case, including the times for loop seal clearance and expanded figures of applicable parameters around the time period of loop seal clearance.

Assess the need for additional noding studies in order to establish PCT variability with loop noding.

ANSWER:

Expanded figures around the time period of loop seal clearance are shown in Figures RAI-15.6.5-70.1 to 10. Figure RAI-15.6.5-70.1 represents the primary pressure transient, and is the expanded figure of Figure 5.4.2-1 in Ref.1. Figure RAI-15.6.5-70.2 represents the downcomer collapsed level, and is the expanded figure of Figure 5.4.2-8 in Ref.1. Figure RAI-15.6.5-70.3 represents the core and upper plenum collapsed levels expanded from Figure 5.4.2-10 in Ref.1 Figure RAI-15.6.5-70.4 represents the PCT transient expanded figure of Figure 5.4.2-11 in Ref.1. Figures RAI-15.6.5-70.5 and 6 represent collapsed level of the broken loop crossover leg downhill side and uphill side, respectively. Figure RAI-15.6.5-70.7 represents the broken loop crossover leg vapor flowrate. Figures RAI-15.6.5-70.8 and 9 represent collapsed level of the intact loop crossover leg downhill side and uphill side, respectively. Figure RAI-15.6.5-70.10 represents the intact loop crossover leg vapor flowrate.

In the fine noding case (labeled as the "sensitivity case" in the figures), the cladding heats up later compared with the base case (Figure RAI-15.6.5-70.4) because upper plenum empties later, and core heat is removed adequately by the down flow from the upper plenum before it empties. And in the fine sensitivity case, the broken loop seal clears earlier than in the base case (at about **[** **]** for base case, about **[** **]** for sensitivity case). Therefore, the turn around of PCT is earlier.

The effect of nodalization on the loop seal behaviors has been assessed using the UPTF Test 5 (SET) and the ROSA-IV/LSTF SB-CL-18 (IET) (Ref.2). And the sensitivity calculation of MUAP-07025-P indicates that the nodalization used for the US-APWR SBLOCA calculations gives a conservative prediction for PCT compared with fine nodalization. In addition, MHI's response to REQUEST CA-1 (Ref.3) demonstrates via several sensitivity calculations that the cladding heat-up is not significant during the loop seal phase. Therefore, MHI judged that there is no need to perform additional noding studies.

References:
1. Mitsubishi Heavy Industries, Ltd., Small Break LOCA Sensitivity Analyses for US-APWR, MUAP-07025-P(R0), December 2007.
2. Mitsubishi Heavy Industries, Ltd., M-RELAP5 Code Supplementary Manual Volume III: Code Assessment, 6AS-1E-UAP-100001 (R0), UAP-HF-10004, January 2010.
3. Mitsubishi Heavy Industries, Ltd., 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 09/08/2009, UAP-HF-09512, November 2009.

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.

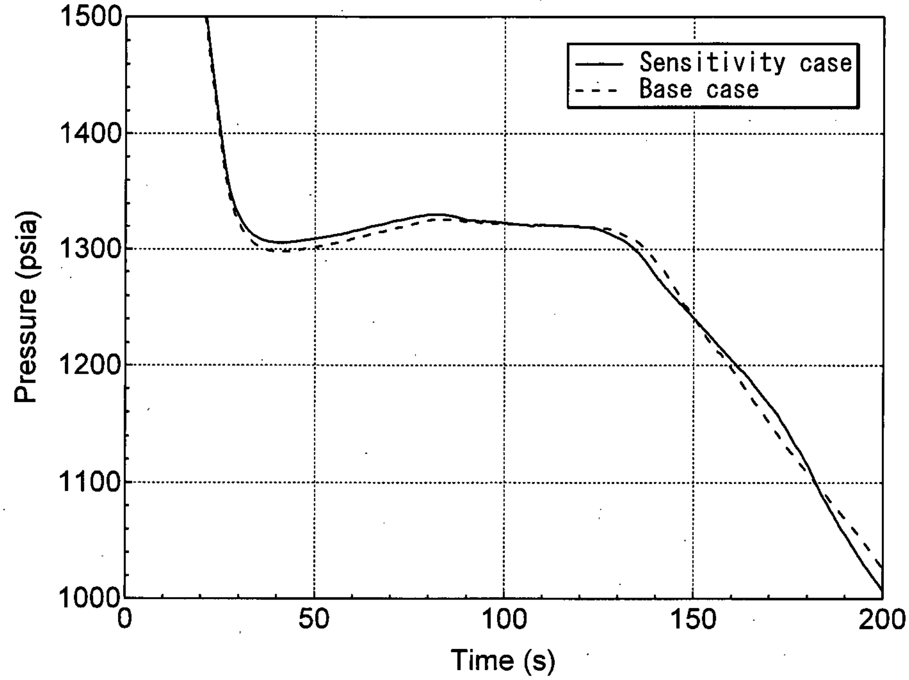

Figure RAI-15.6.5-70.1 Primary Pressure

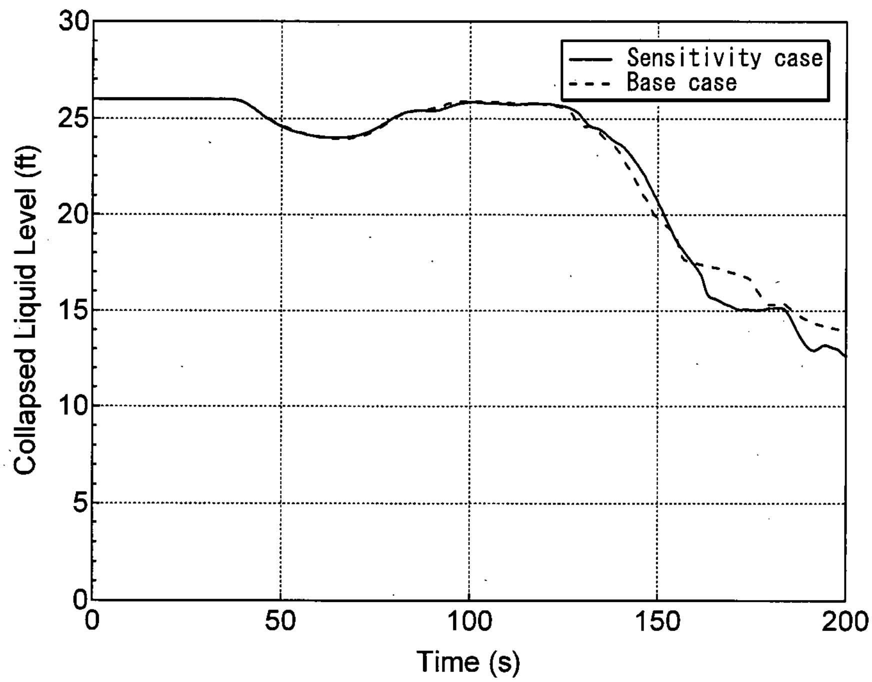

Figure RAI-15.6.5-70.2 Downcomer Collapsed Level

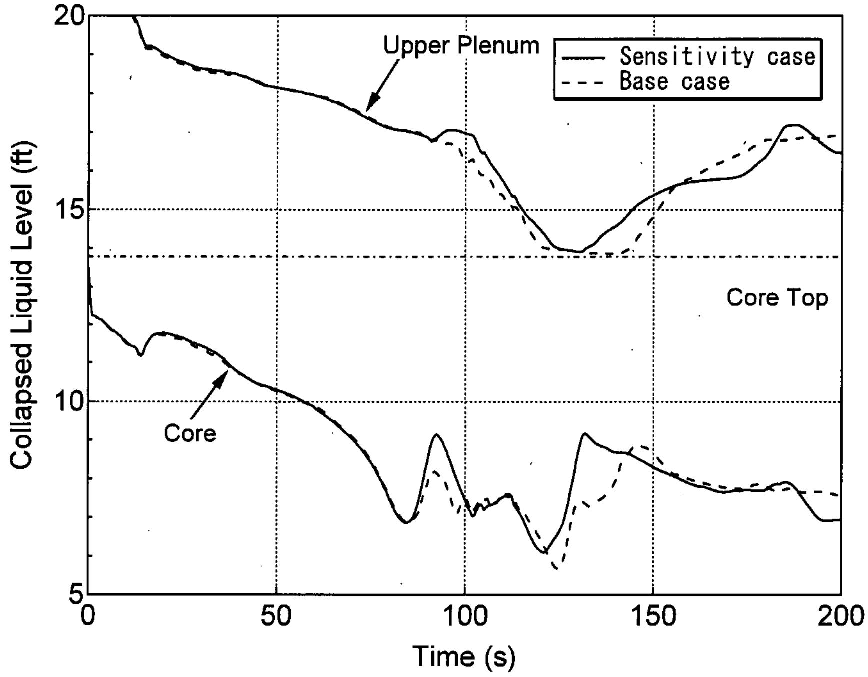

Figure RAI-15.6.5-70.3 Hot Assembly Core and Upper Plenum Collapsed Levels

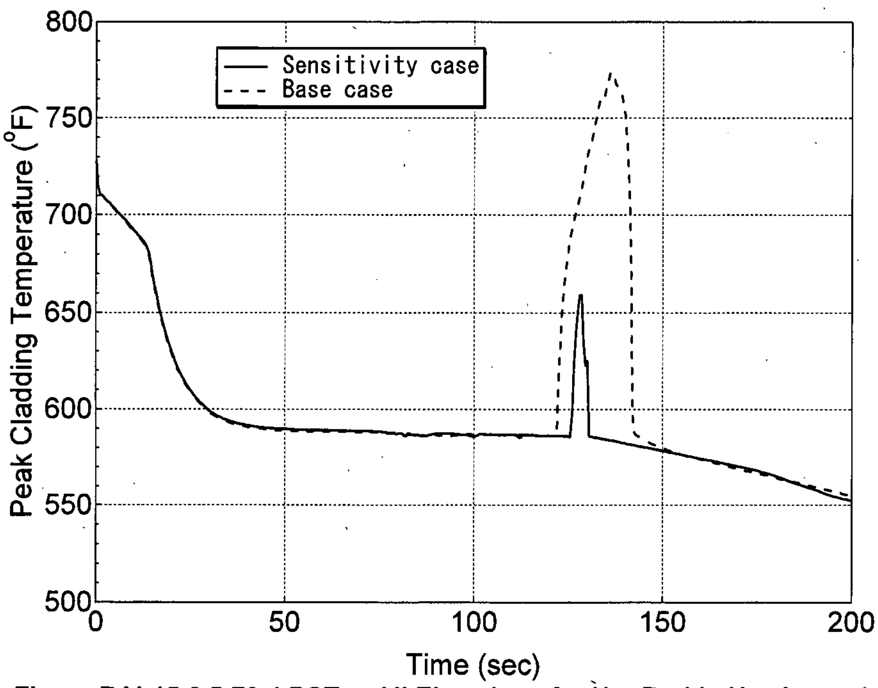

Figure RAI-15.6.5-70.4 PCT at All Elevations for Hot Rod in Hot Assembly

Figure RAI-15.6.5-70.5 Broken Loop Crossover Leg Downhill Side Collapsed Level

Figure RAI-15.6.5-70.6 Broken Loop Crossover Leg Uphill Side Collapsed Level

Figure RAI-15.6.5-70.7 Broken Loop Crossover Leg Vapor Flowrate

Figure RAI-15.6.5-70.8 Intact Loop Crossover Leg Downhill Side Collapsed Level

Figure RAI-15.6.5-70.9 Intact Loop Crossover Leg Uphill Side Collapsed Level

Figure RAI-15.6.5-70.10 Intact Loop Crossover Leg Vapor Flowrate

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SRP SECTION: 15.06.05 – LOSS OF COOLANT ACCIDENTS RESULTING FROM SPECTRUM OF POSTULATED PIPING BREAKS WITHIN THE REACTOR COOLANT PRESSURE BOUNDARY

APPLICATION SECTION: DCD CHAPTER 15.6.5. SMALL BREAK LOCA

DATE OF RAI ISSUE: 12/17/2009

QUESTION NO.: 15.06.05-72

Section 5.5 of MUAP-07025-P provides a time step size sensitivity study for a 7 ½-inch top cold-leg SBLOCA. Figure 5.5.a-5 shows notable difference in the accumulator injection flow oscillations at points beyond 400 seconds into the transient.

Explain the phenomenon and its sensitivity to the specified maximum time step size, and the acceptability of the numerical error implied by these results.

ANSWER:

[

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The above mechanism explains the oscillatory behavior in the accumulator injection flowrate, which is confirmed by temporal change of the accumulator tank pressure as shown in Figure RAI-15.06.05-72.1. The sensitivity calculations show that this oscillation becomes larger when the applied maximum time step size is bigger. When the time step size is smaller, the accumulator smoothly and continuously injects the safety coolant as shown in Figure 5.5.a-5 of

MUAP-07025-P.

In the 7.5-in cold leg top break, however, the accumulator injection and its oscillatory behavior appear after the core is quenched and recovered, resulting in no sensitivity on the PCT. The PCT sensitivity appearing when the applied maximum time step size is halved is negligibly small as shown in Table 5.5.a-2. Therefore, the time-step sensitivity is sufficiently acceptable.

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.

Figure RAI-15.06.05-72.1 Accumulator Tank Pressure

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APPLICATION SECTION:	DCD CHAPTER 15.6.5. SMALL BREAK LOCA
DATE OF RAI ISSUE:	12/17/2009

QUESTION NO.: 15.06.05-73

Section 5.5 of MUAP-07025-P provides a time step size sensitivity study for a 1-ft^2 top cold-leg SBLOCA. Figure 5.5.b-3 shows that the time step sensitivity case does not calculate several of the liquid discharge rate peaks at points beyond 300 seconds into the transient.

Explain the phenomenon and its sensitivity to the specified maximum time step size, and the acceptability of the numerical error implied by these results.

ANSWER:

[

]

The oscillatory behavior described above obviously appears after the fuel cladding temperature reached the peak value as shown in Figure 5.5.b-11 of MUAP-07025-P. Therefore, the time step size sensitivity on PCT for the 1-ft^2 cold leg top break is negligibly small as confirmed in Table 5.5.b-2, and is sufficiently acceptable from the viewpoint of the safety analysis.

References:

1. Mitsubishi Heavy Industries, Ltd., MHI's 2nd Response to the NRC's Request for Additional Information on Topical Report MUAP-0701.3-P (R0) "Small Break LOCA Methodology for US-APWR" on 09/08/2009, UAP-HF-09512, November 2009.
2. NRC, Draft Request for Additional Information US-APWR Topical Report: Small Break LOCA Methodology MUAP-07013-P (R0), January 21, 2010.

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:	**DCD CHAPTER 15.6.5: SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-74

Figures 8.2.1-37 and 8.2.1-38 show the measured and predicted rod surface temperatures, respectively. However, it is very difficult to distinguish the temperatures given at several elevations. Please provide figures which show the temperatures clearly.

ANSWER:

MHI's response to the present QUESTION was given previously in MHI's response to RAI 8.2.1-14 in Reference 1.

Reference:

1. Mitsubishi Heavy Industries, Ltd., MHI's 1st Response to the NRC's Request for Additional Information on Topical Report MUAP-07013-P (RO) "Small Break LOCA Methodology for US-APWR" on 09/08/2009, UAP-HF-09492, October 2009.

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:	**DCD CHAPTER 15.6.5. SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-75

Section 5.5 of MUAP-07025-P provides a time step size sensitivity study for a 1-ft^2 top cold-leg SBLOCA. Figure 5.5.b-5 shows that the time step sensitivity case results in lower accumulator injection rates between approximately 175 seconds and 275 seconds into the transient, affecting inventory levels, core uncover, and PCT results.

Assess the variability of the results with time step size and justify the choice of the base case evaluation model maximum time step size.

ANSWER:

As pointed out by the NRC, the accumulator flowrate between approximately 175 seconds and 275 seconds and the quenching timing are different. But the differences do not affect the PCT because the PCT occurs at 166 seconds, earlier than the occurrence of the differences between two cases. In addition, the time step size used in the DCD analyses is determined considering the impact on the PCT. Therefore, MHI choses [ ] of the specified maximum time step size as the base case evaluation model [ ].

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:	**DCD CHAPTER 15.6.5. SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-76

Section 5.6 of MUAP-07025-P provides an off-site power available sensitivity study for a 7 ½-inch top cold-leg SBLOCA and a 1-ft^2 top cold-leg SBLOCA. Tables 5.6.2-1 and 5.6.2-3 show RCP Trip for the non-LOOP cases occurring exactly 18 seconds following ECCS actuation, not 15 seconds as described in FSAR Section 7.3.1.5.1 and depicted in FSAR Figure 7.2-2 sheet 11.

Explain the apparent discrepancy between the SBLOCA analysis assumption and the US APWR design description contained in the FSAR.

ANSWER:

[

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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:	**DCD CHAPTER 15.6.5. SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-77

The PCT values reported in the US APWR DCD FSAR Section 15.6.5 do not exactly agree with the values reported in MUAP-07025-P.

- For the 7½-inch Top Cold-Leg break, MUAP-07025-P Table 5.5.a-2 reports PCT = 775°F whereas FSAR Section 15.6.5.3.3.2 reports PCT = 774°F.
- For the 1-ft^2 Top Cold-Leg break, MUAP-07025-P Table 5.5.b-2 reports PCT = 1297°F whereas FSAR Section 15.6.5.3.3.2 reports PCT = 1317°F.

Explain this discrepancy.

ANSWER:

The reviewer refers to the updated PCT values reported in the DCD FSAR Revision 1 issued in August 2008.

The PCT values shown in MUAP-07025-P were the initial analysis results reported in the DCD Revision 0, issued to the NRC on December 31, 2007 for the US-APWR application review.

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:	**DCD CHAPTER 15.6.5. SMALL BREAK LOCA**
DATE OF RAI ISSUE:	**12/17/2009**

QUESTION NO.: 15.06.05-78

MUAP-07025-P Section 5.4.1 part (1) states that the accumulator injection rates for the base case and sensitivity case for the 7 ½ -inch cold-leg top break noding study are perfectly in agreement. The referenced Figure 5.4.1-5, however, does not demonstrate that the results are identical.

Clarify the assessment of accumulator injection rate provided in the text of Section 5.4.1 relative to the results shown in Figure 5.4.1-5.

ANSWER:

The reviewer is correct. The term "perfectly in agreement" was inappropriate and misleading. The revised statement is *"The calculation results of base case and sensitivity case are similar in terms of transient profile, magnitude and duration."*

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.