MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

February 15, 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-10042

Subject: MHI's 2nd 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 2nd Response to US-APWR DCD RAI No. 514-4040 Revision 2'. In the enclosed document, MHI provides the 3 (three) out of 21 (twenty-one) items requested in Reference 1. The remaining responses to the RAI in Reference 1 were transmitted to the NRC by separate correspondence on February 5, 2010 (45 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.

D081
NRO

Enclosures:

1. Affidavit of Yoshiki Ogata

2. MHI's 2nd Response to US-APWR DCD RAI No. 514-4040 Revision 2 (Proprietary)

3. MHI's 2nd Response to US-APWR DCD RAI No. 514-4040 Revision 2 (Non-Proprietary)

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

Contact Information
C. Keith Paulson, Senior Technical Manager
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Telephone: (412) 373 – 6466

ENCLOSURE 1

Docket No.52-021
MHI Ref: UAP-HF-10042

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 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 15th day of February, 2010.

Y. Ogata

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

ENCLOSURE 3

UAP-HF-10042

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

February 2010
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/15/2010

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.: 15.06.05-61

Table 2-1 of MUAP-07025-P states that Appendix K Requirement # 16 noding near the ECC water injection points will be appropriate, as described in Section 3 of MUAP-07025-P. Appendix K requires that the noding at the injection points be chosen to ensure reliable analysis of the thermodynamics during blowdown.

Provide additional explanation of the adequacy of the model noding near the ECC injection points, including the rationale for not performing injection point noding sensitivity studies. The effects of steam leakage from the reactor vessel upper head region into the downcomer should be addressed.

ANSWER:

Sensitivity calculations with a fine noding near the DVI injection points were performed. **[** **]** The vessel side noding scheme for this sensitivity calculation is shown in **Figure RAI-15.06.05-61.1**. The results are shown in **Figures RAI-15.06.05-61.2 to 8** for the 7.5-inch break, and in **Figures RAI-15.06.05-61.9 to 15** for the 1-ft^2 break, where the sensitivity cases are compared with the DCD case. The PCT is listed in **Table RAI-15.06.05-61.1**. For both break size cases, the impact of the noding scheme on the condensation rate by the ECC water is not significant, and the resultant PCTs are similar to those of the DCD cases. Therefore, the noding sensitivity near the DVI injection point does not have a significant impact on the SBLOCA analysis.

Sensitivity calculations with a finer noding scheme for the upper downcomer region, in combination with the finer DVI noding described above, were also performed. **[** **]** The vessel side noding scheme for this sensitivity calculation is shown in **Figure RAI-15.06.05-61.16**. The results are shown in **Figures RAI-15.06.05-61.17 to 23** for the 7.5-inch break, and in **Figures RAI-15.06.05-61.24 to 30** for the 1-ft^2 break, respectively. The PCT is shown in **Table RAI-15.06.05-61.1**. For the 7.5-inch break size case, the resultant PCT is similar to that of the DCD case. For the 1-ft^2 break case, the initiation of heat-up timing is later **[** **]**

[

] (**Figure RAI-15.06.05-61.31**). The resultant PCT is lower than that of the DCD case, and it can be judged that the noding scheme used for the DCD is conservative.

Therefore, the current noding scheme for the DCD calculations is appropriate from the safety analysis point of view.

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.

Table RAI-15.06.05-61.1 Peak Cladding Temperature (Cold Leg Top-Break)

Break Size	7.5-in	1-ft^2
DCD Case	773 °F	1323 °F
Sensitivity Case 1	770 °F	1307 °F
Sensitivity Case 2	767 °F	1260 °F

Figure RAI-15.06.05-61.1 Noding shceme for Sensitivity Case 1

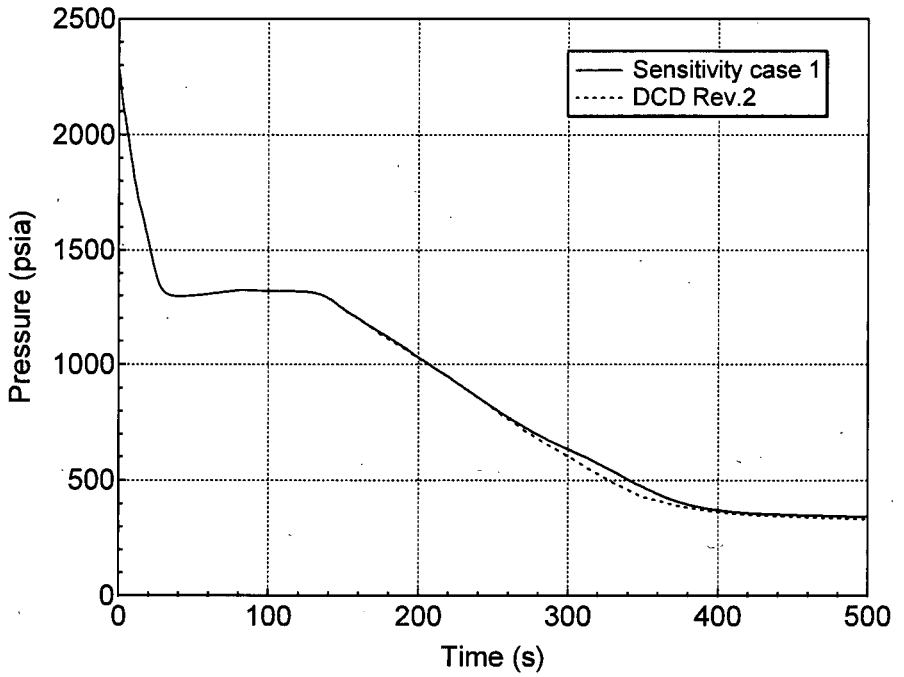

Figure RAI-15.06.05-61.2 RCS (Pressurizer) Pressure Transient for 7.5-inch Small Break LOCA (Sensitivity Case 1)

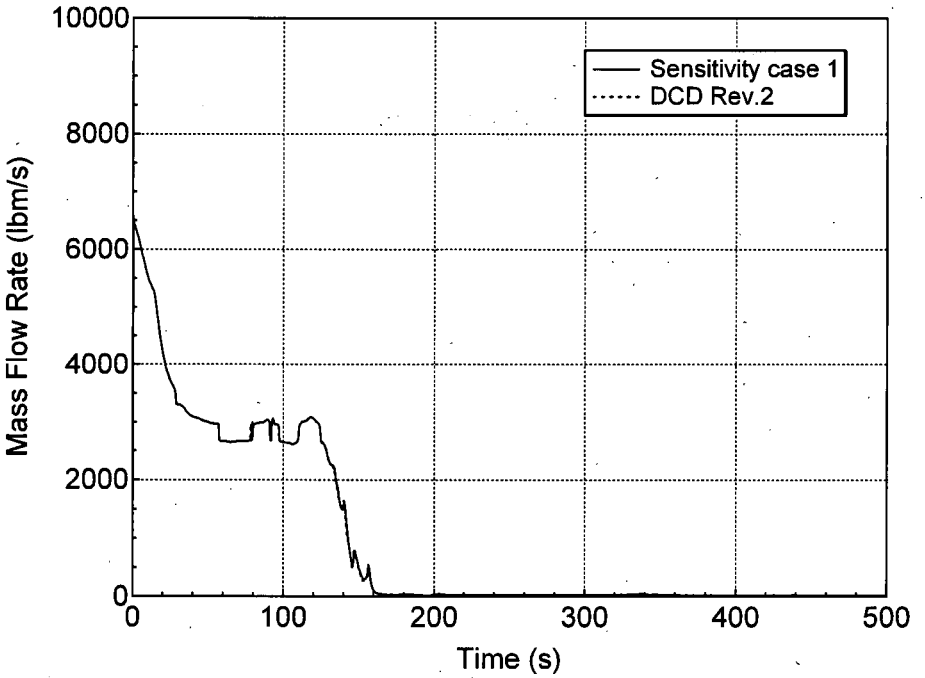

Figure RAI-15.06.05-61.3 Liquid Discharge through the Break for 7.5-inch Small Break LOCA (Sensitivity Case 1)

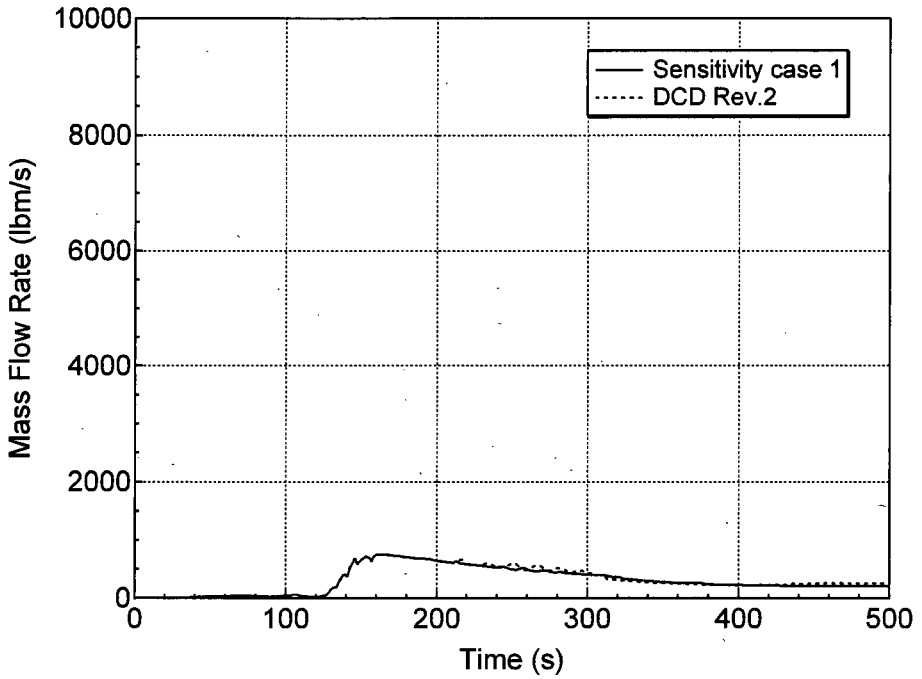

Figure RAI-15.06.05-61.4 Vapor Discharge hrough the Break for 7.5-inch Small Break LOCA (Sensitivity Case 1)

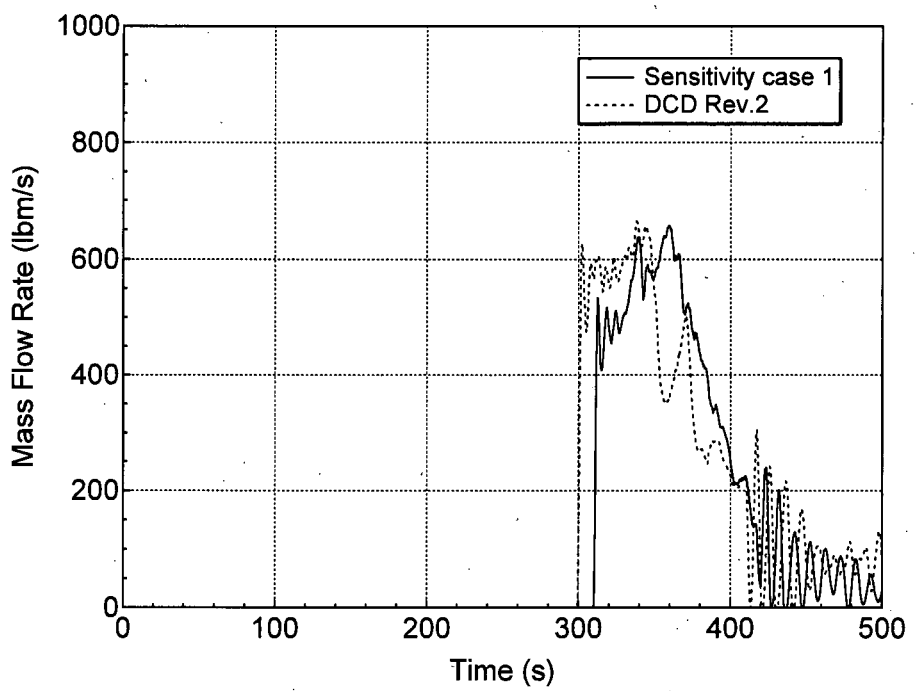

Figure RAI-15.06.05-61.5 Accumulator Mass Flowrates for 7.5-inch Small Break LOCA (Sensitivity Case 1)

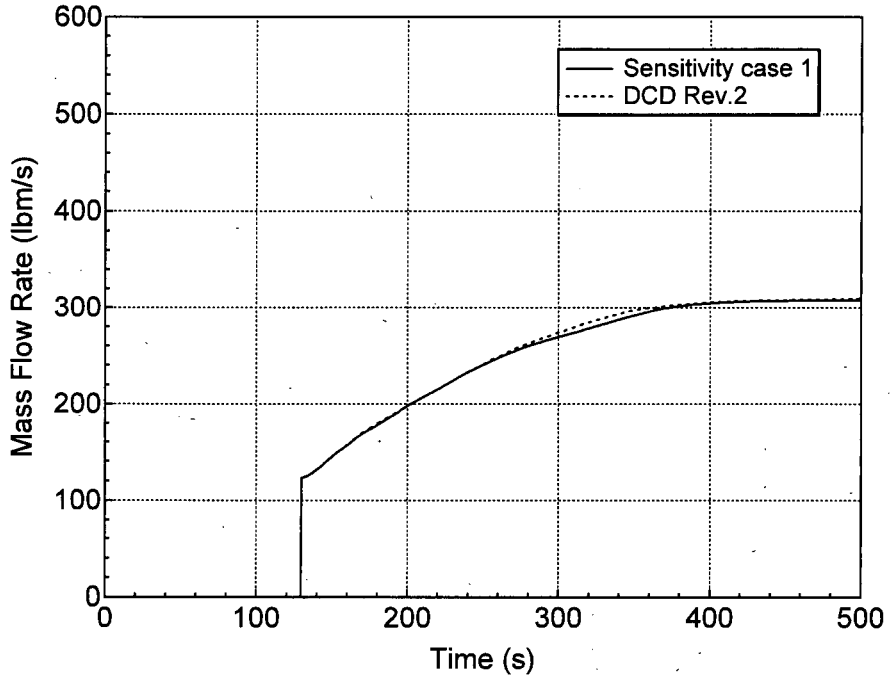

Figure RAI-15.06.05-61.6 Safety Injection Mass flowrates for 7.5-inch Small Break LOCA (Sensitivity Case 1)

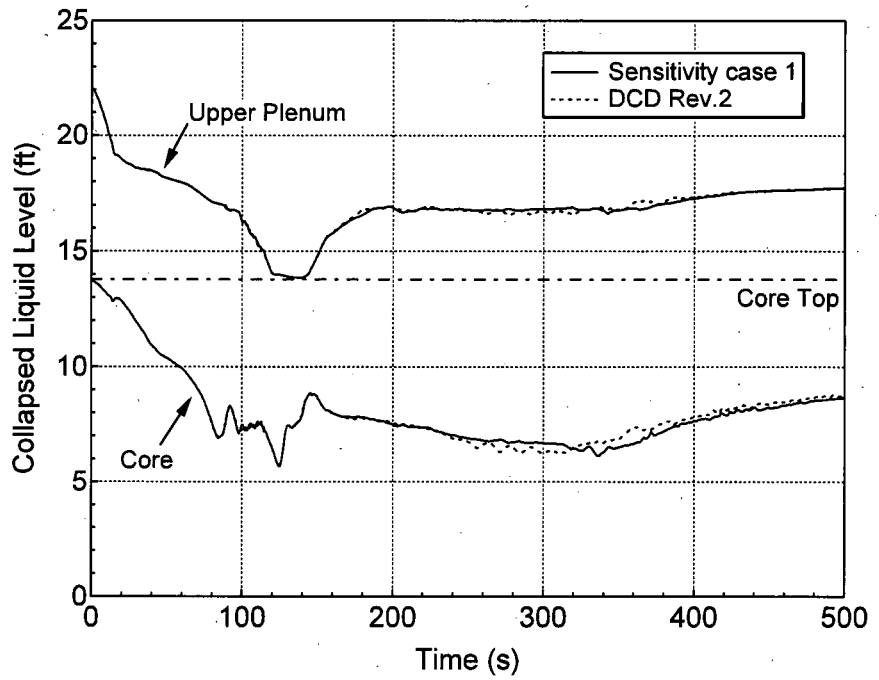

Figure RAI-15.06.05-61.7 Core/Upper Plenum Collapsed Level for 7.5-inch Small Break LOCA (Sensitivity Case 1)

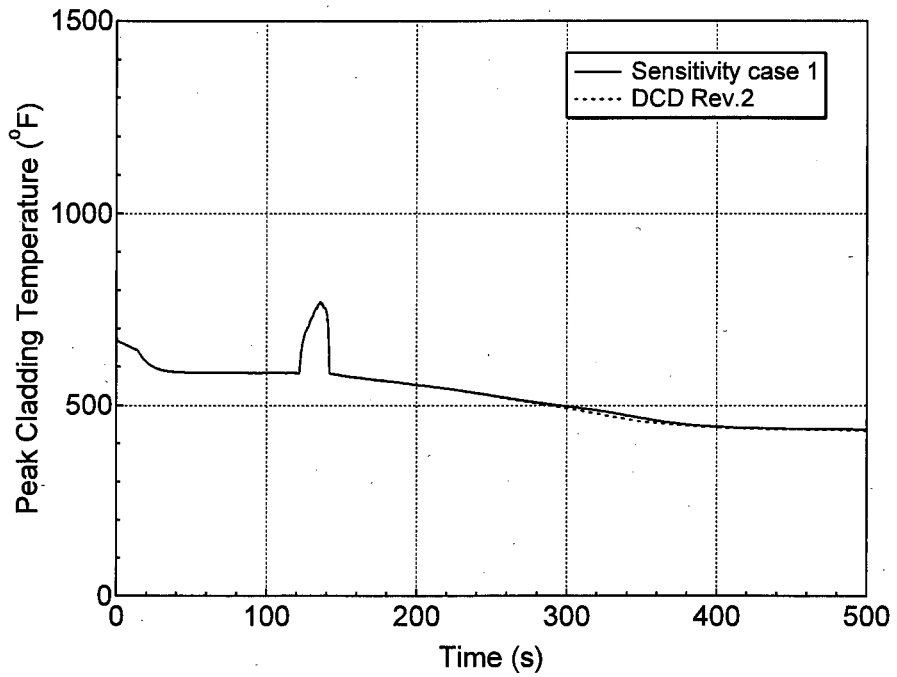

Figure RAI-15.06.05-61.8 PCT at All Elevations for Hot Rod in Hot Assembly for 7.5-inch Small Break LOCA (Sensitivity Case 1)

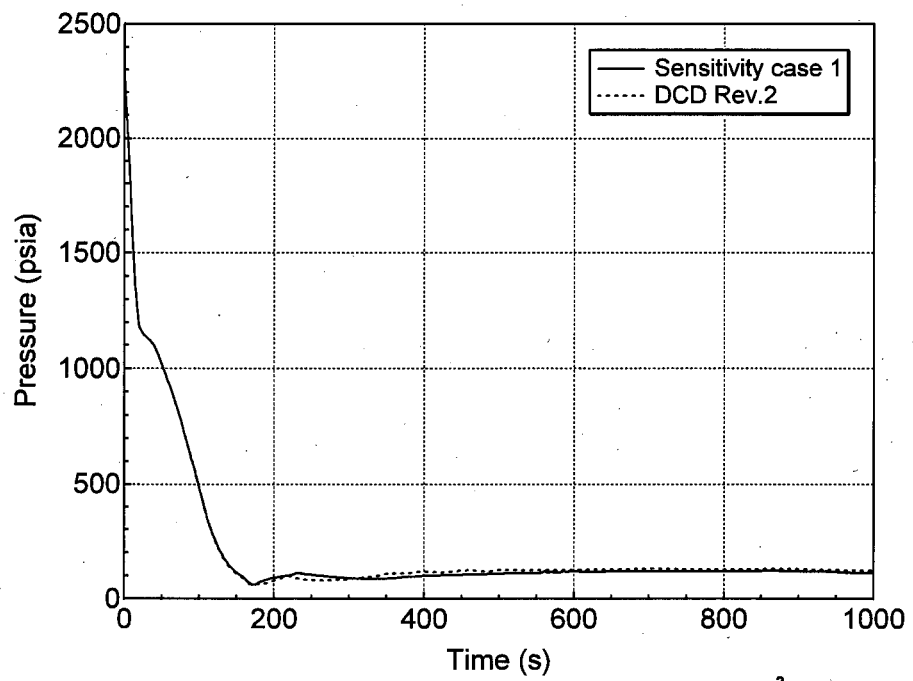

Figure RAI-15.06.05-61.9 RCS (Pressurizer) Pressure Transient for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

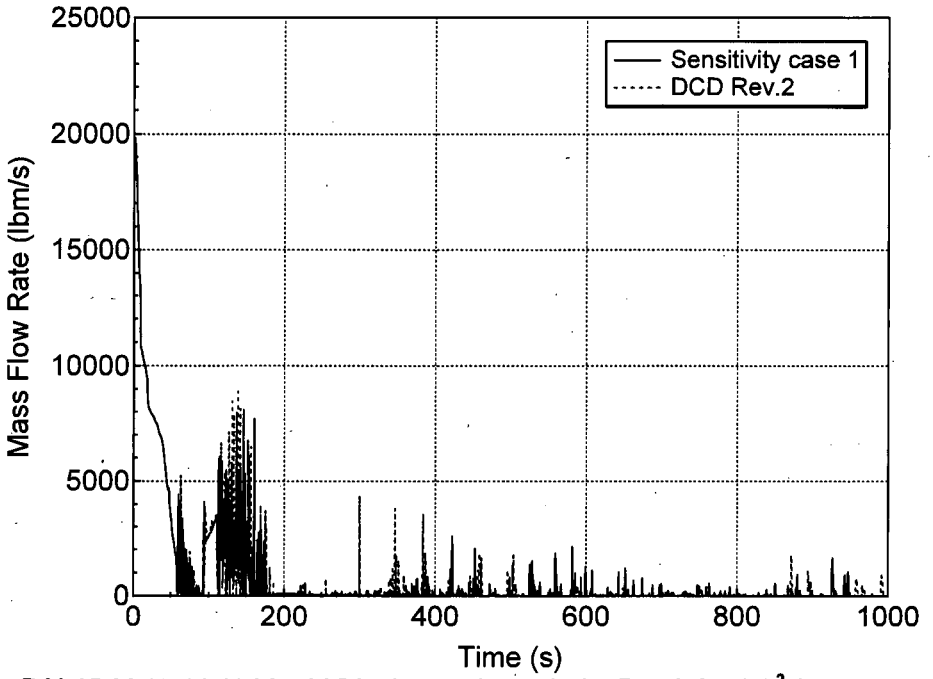

Figure RAI-15.06.05-61.10 Liquid Discharge through the Break for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

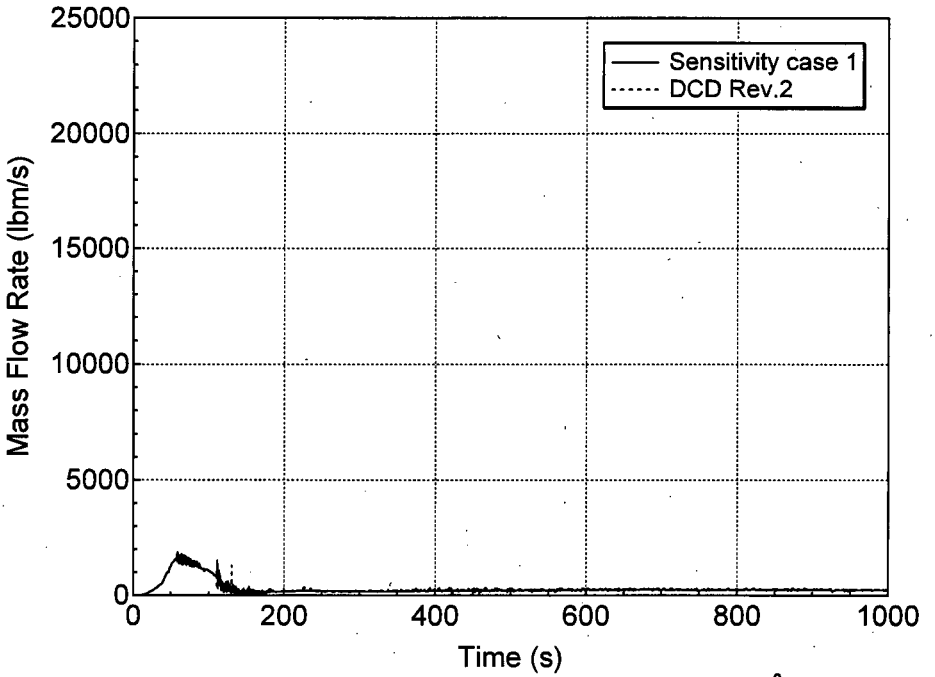

Figure RAI-15.06.05-61.11 Vapor Discharge through the Break for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

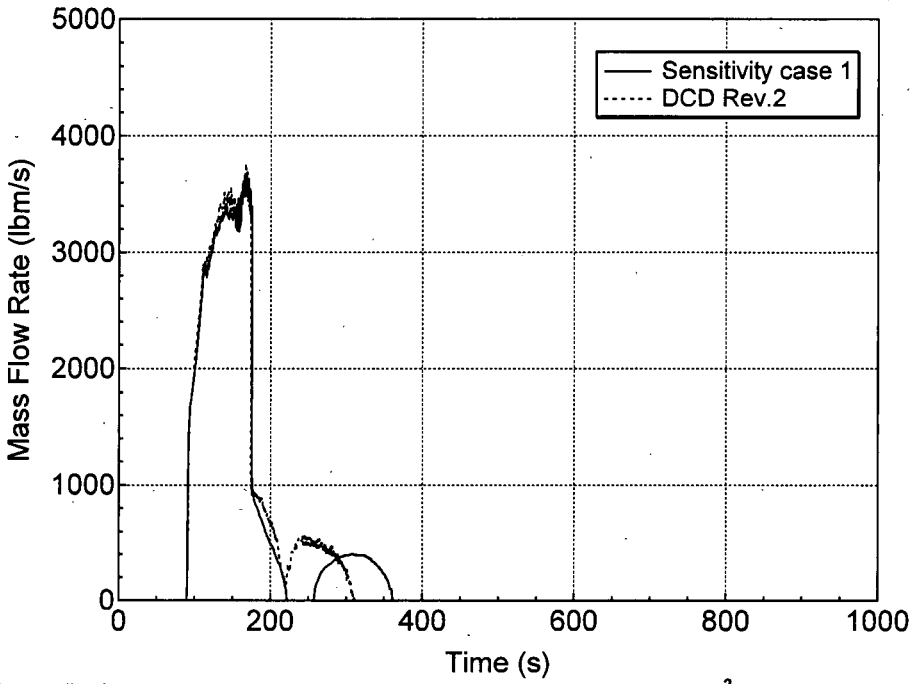

Figure RAI-15.06.05-61.12 Accumulator Mass Flowrate for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

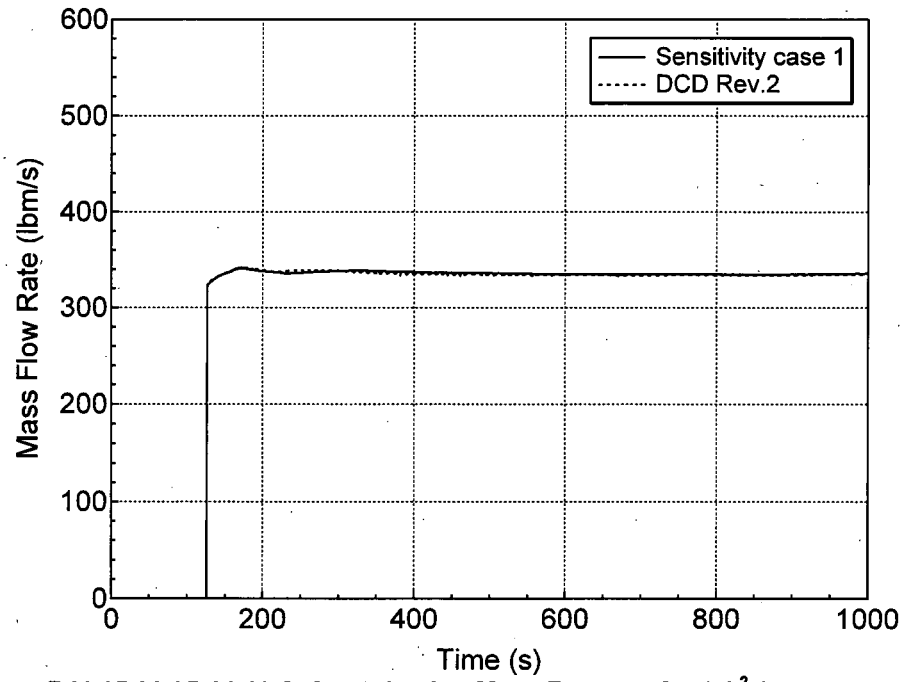

Figure RAI-15.06.05-61.13 Safety Injection Mass Flowrate for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

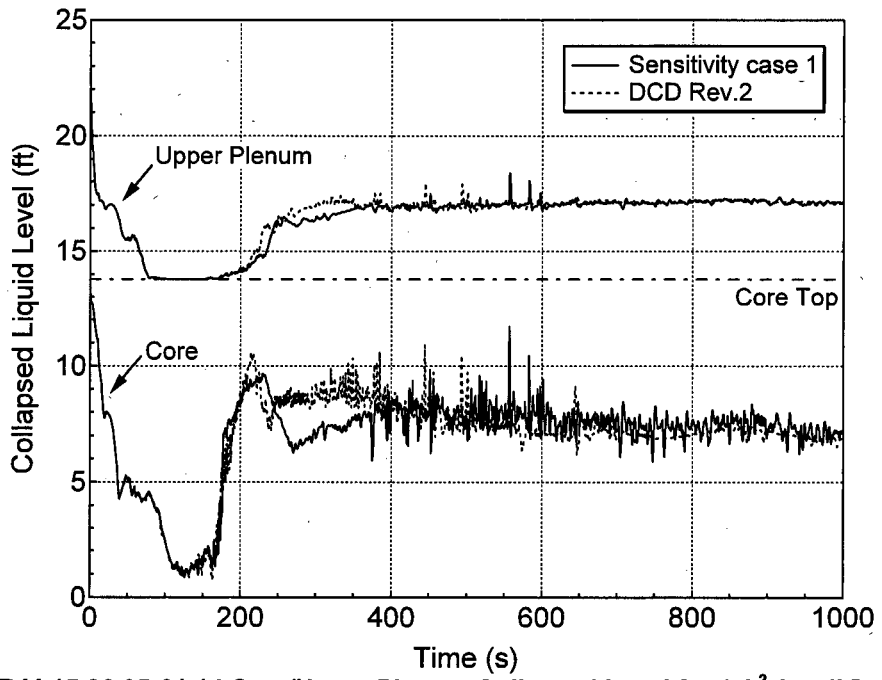

Figure RAI-15.06.05-61.14 Core/Upper Plenum Collapsed Level for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

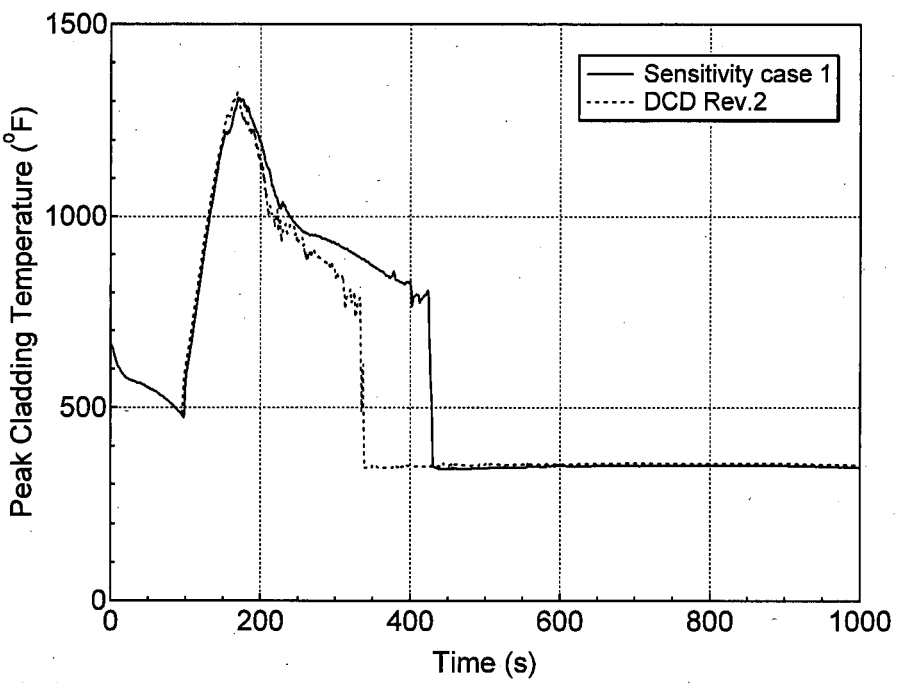

Figure RAI-15.06.05-61.15 PCT at All Elevations for Hot Rod in Hot Assembly for 1-ft^2 Small Break LOCA (Sensitivity Case 1)

Figure RAI-15.06.05-61.16 Noding shceme for Sensitivity Case 2

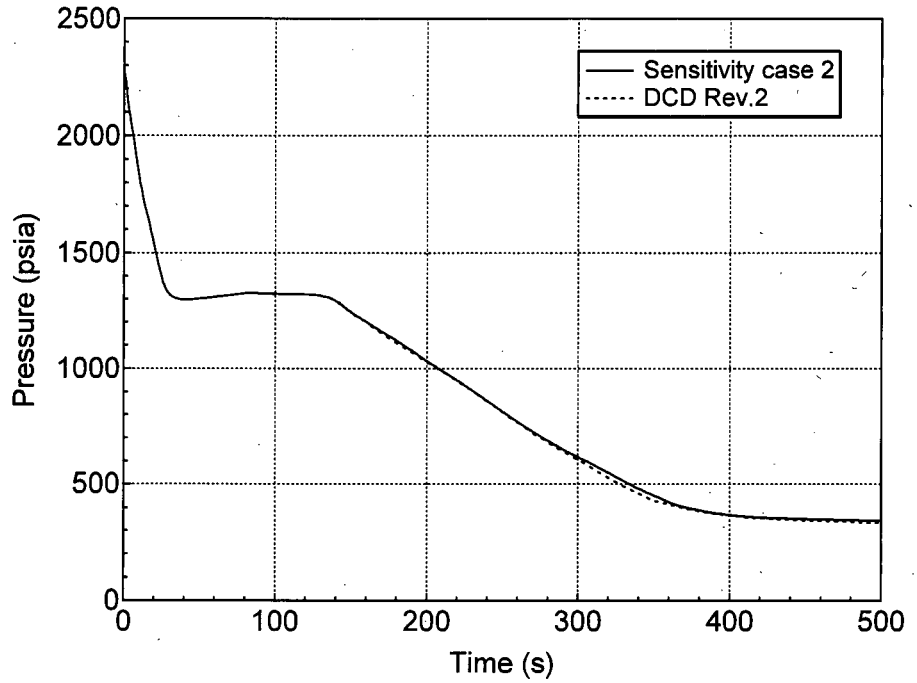

Figure RAI-15.06.05-61.17 RCS (Pressurizer) Pressure Transient for 7.5-inch Small Break LOCA (Sensitivity Case 2)

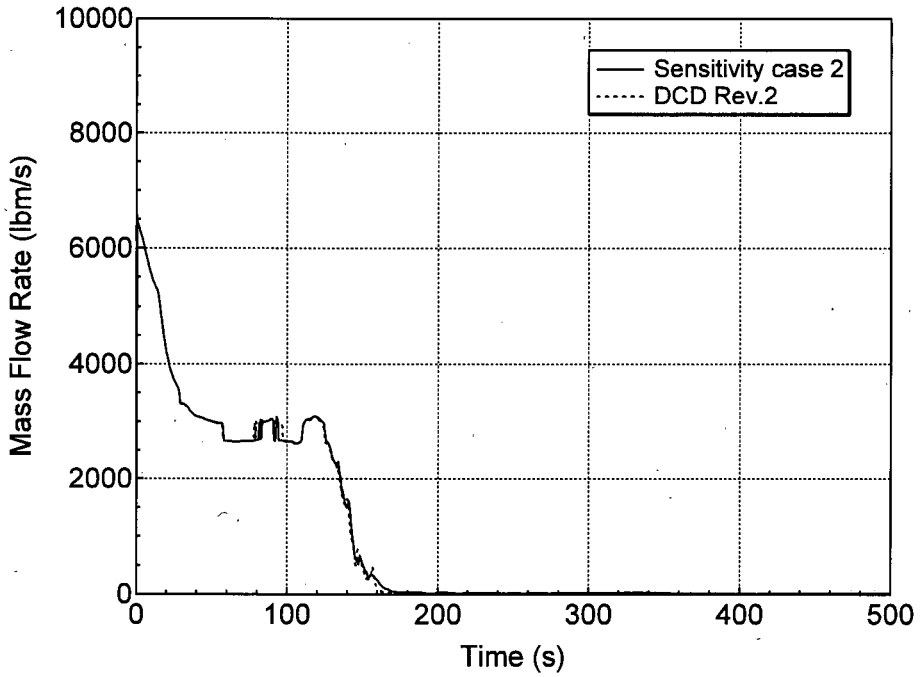

Figure RAI-15.06.05-61.18 Liquid Discharge through the Break for 7.5-inch Small Break LOCA (Sensitivity Case 2)

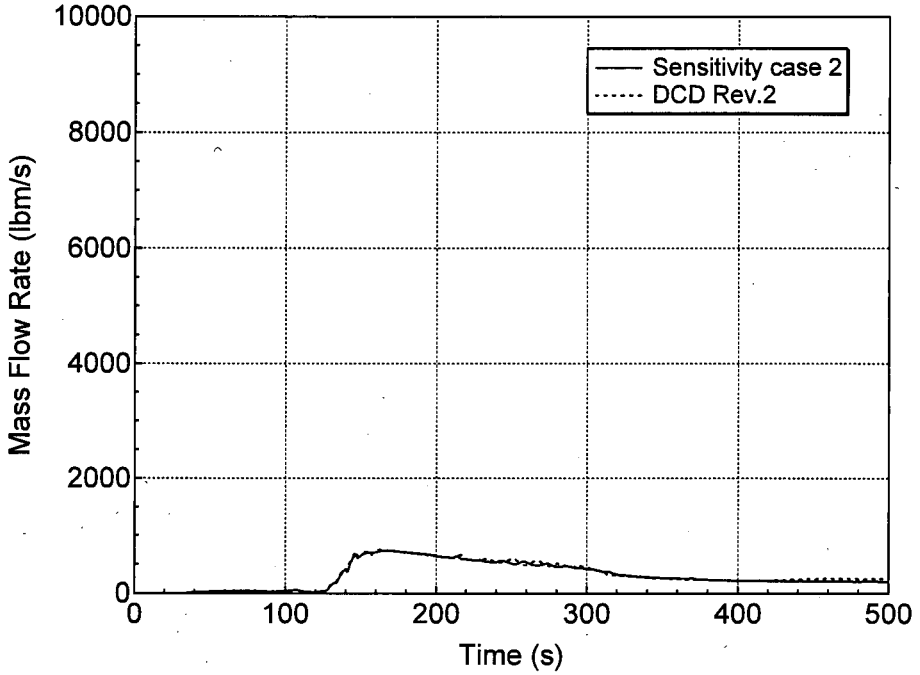

Figure RAI-15.06.05-61.19 Vapor Discharge through the Break for 7.5-inch Small Break LOCA (Sensitivity Case 2)

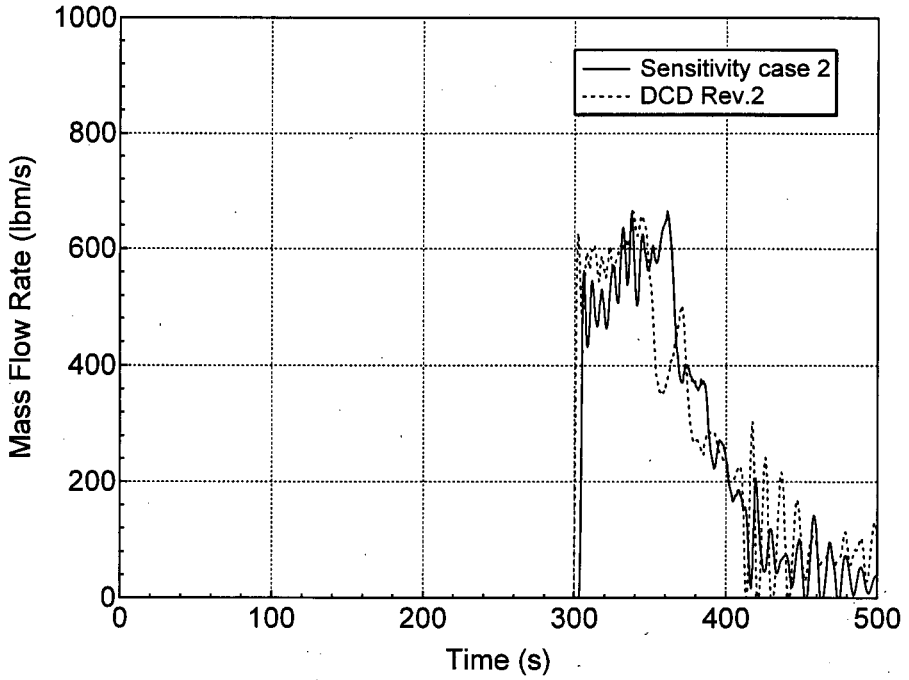

Figure RAI-15.06.05-61.20 Accumulator Mass Flowrate for 7.5-inch Small Break LOCA (Sensitivity Case 2)

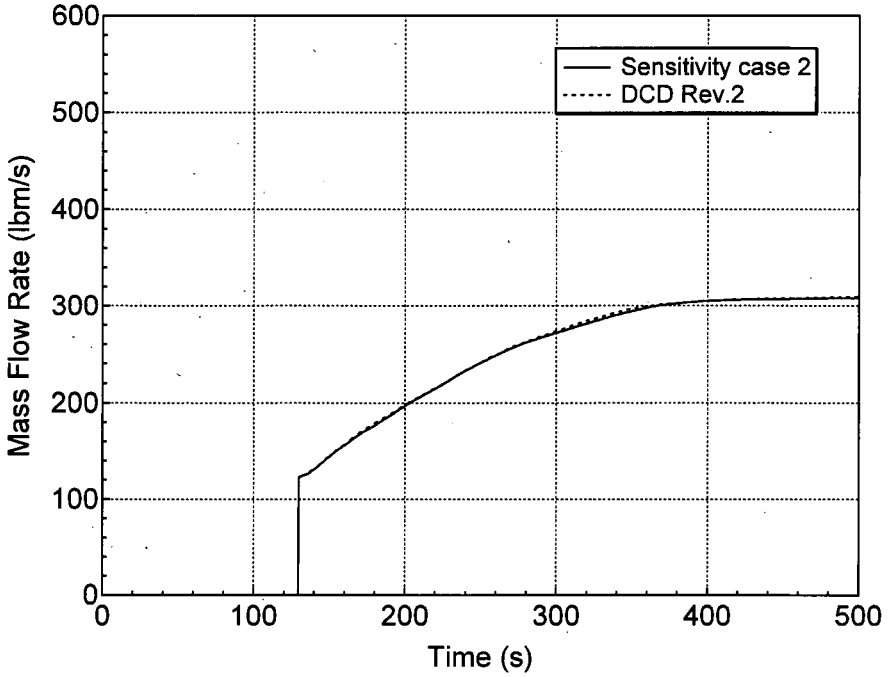

Figure RAI-15.06.05-61.21 Safety Injection Mass Flowrate for 7.5-inch Small Break LOCA (Sensitivity Case 2)

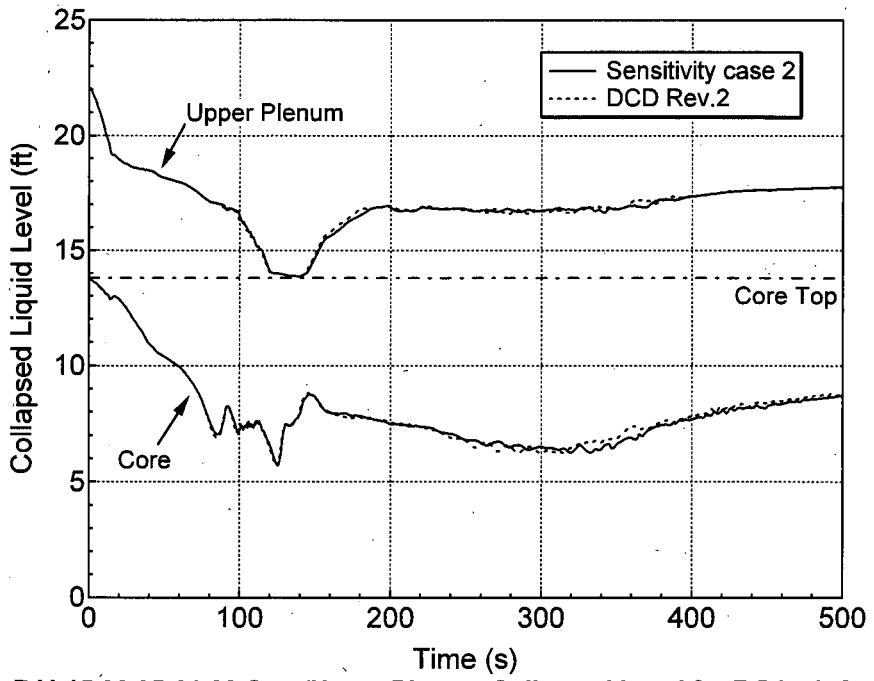

Figure RAI-15.06.05-61.22 Core/Upper Plenum Collapsed Level for 7.5-inch Small Break LOCA (Sensitivity Case 2)

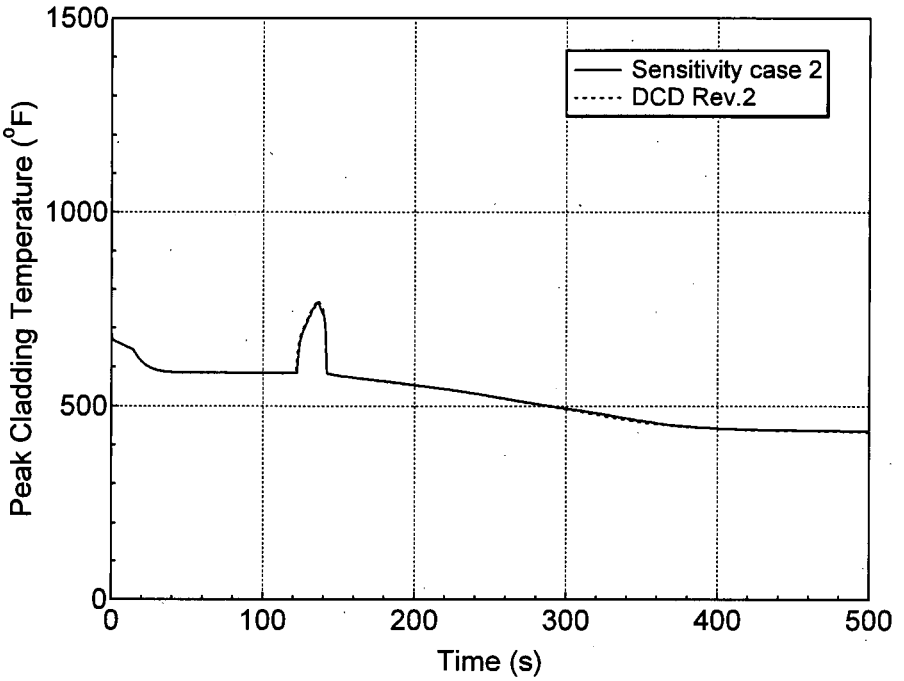

Figure RAI-15.06.05-61.23 PCT at All Elevations for Hot Rod in Hot Assembly for 7.5-inch Small Break (Sensitivity Case 2)

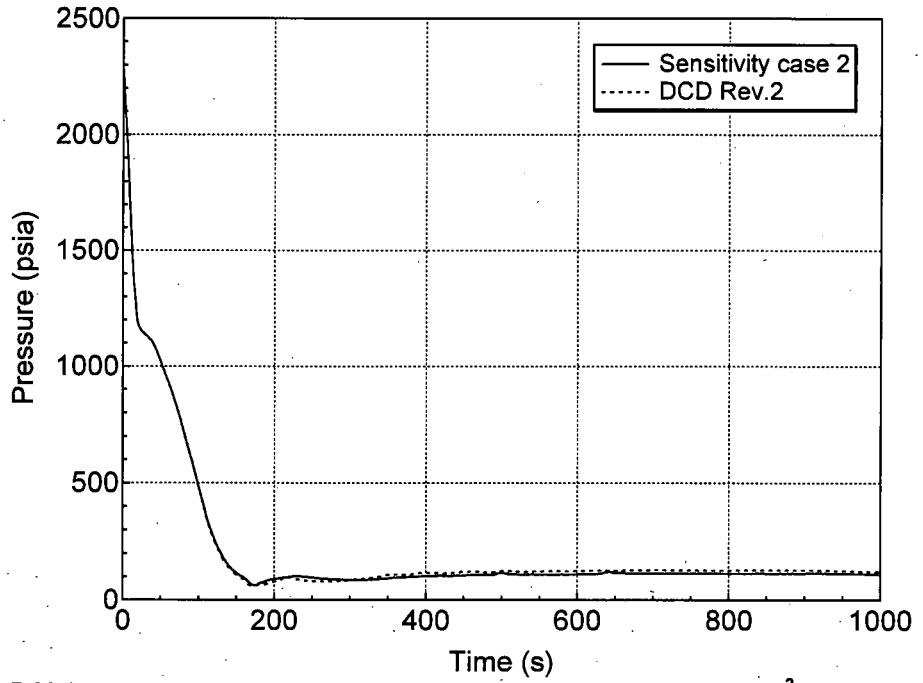

Figure RAI-15.06.05-61.24 RCS (Pressurizer) Pressure Transient for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

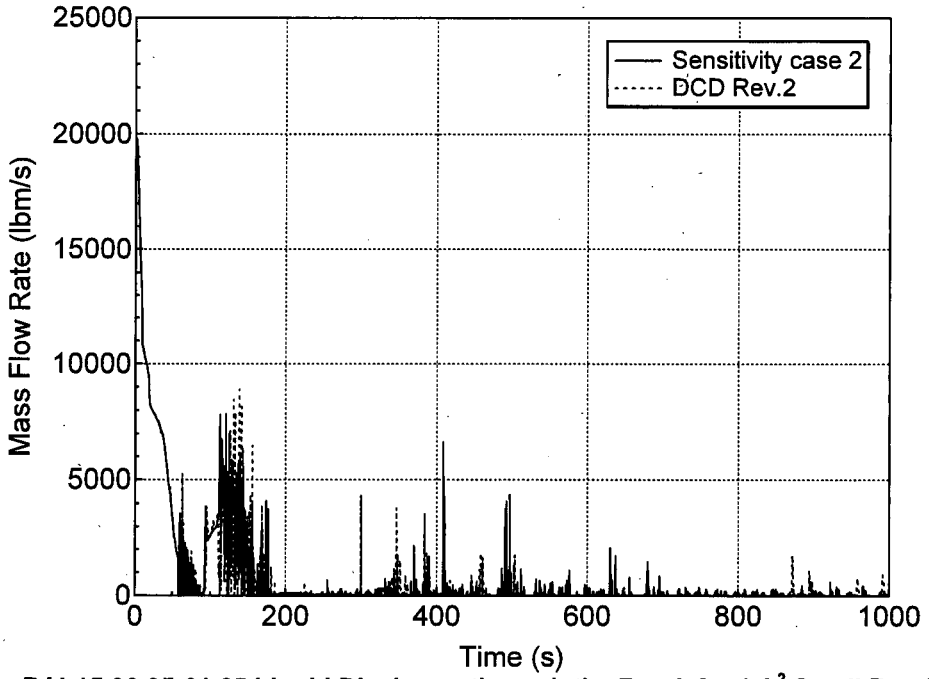

Figure RAI-15.06.05-61.25 Liquid Discharge through the Break for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

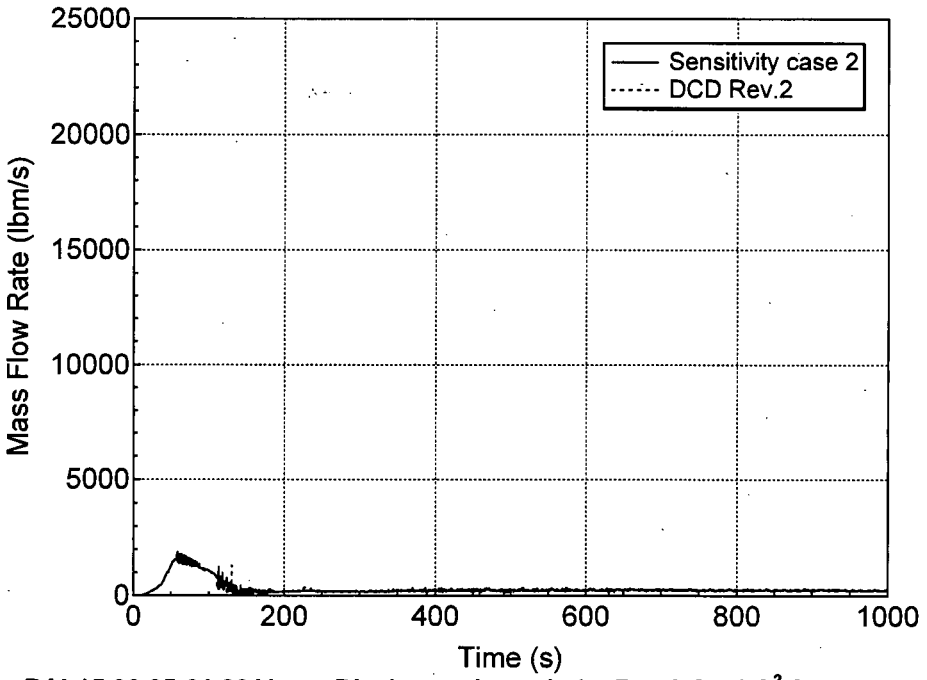

Figure RAI-15.06.05-61.26 Vapor Discharge through the Break for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

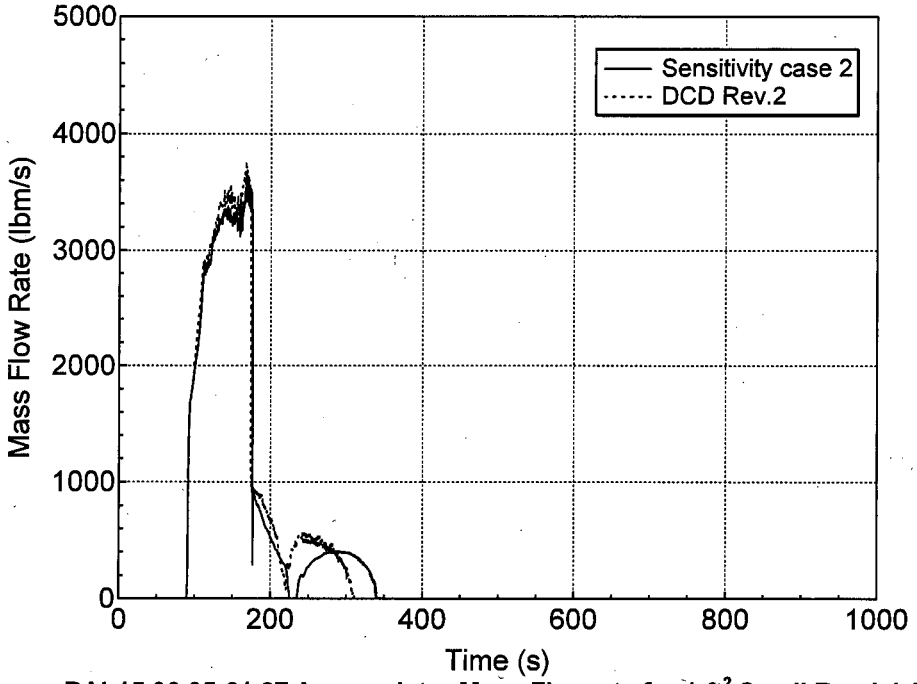

Figure RAI-15.06.05-61.27 Accumulator Mass Flowrate for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

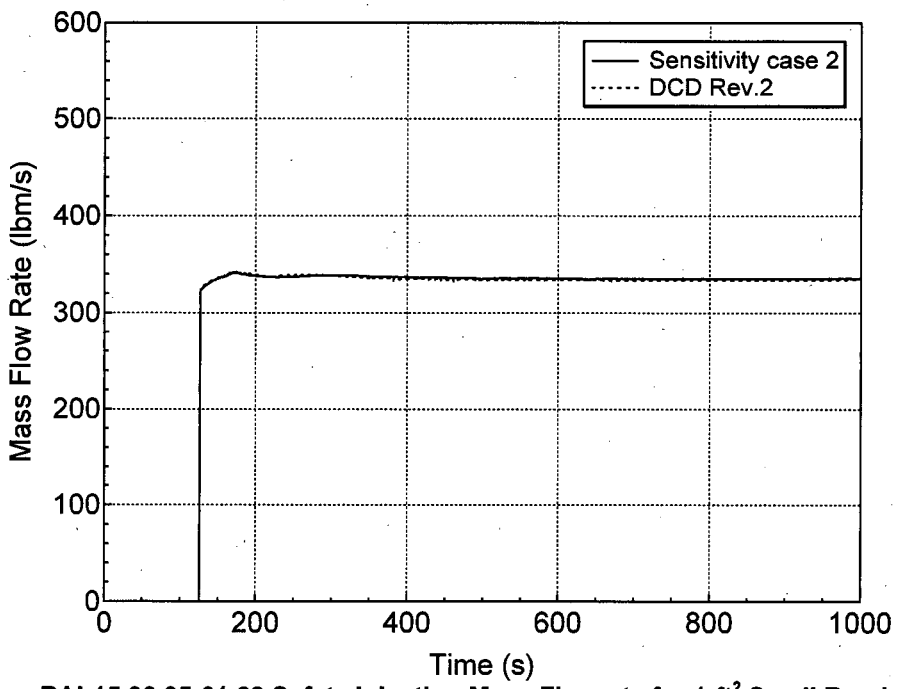

Figure RAI-15.06.05-61.28 Safety Injection Mass Flowrate for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

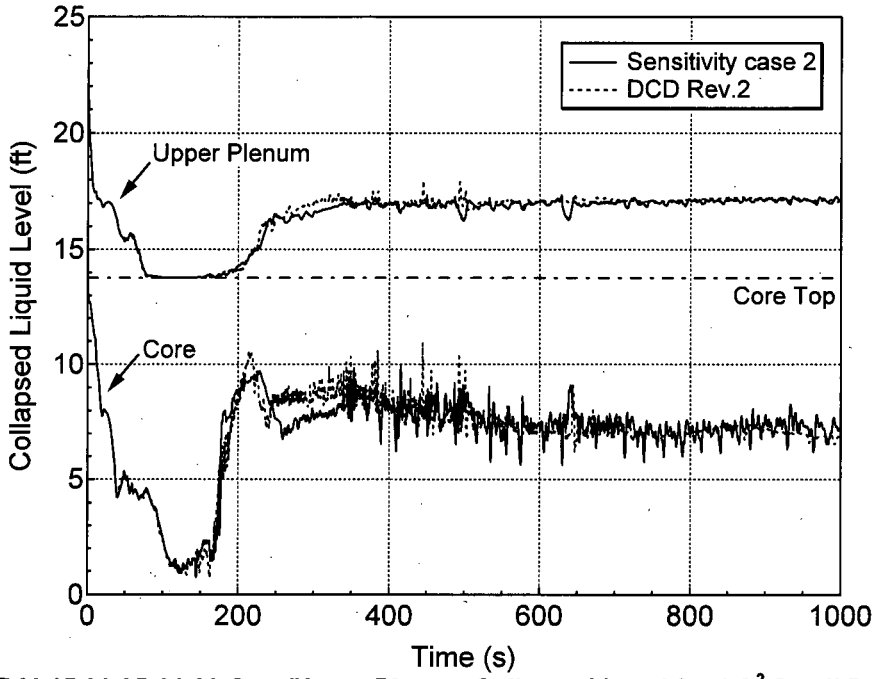

Figure RAI-15.06.05-61.29 Core/Upper Plenum Collapsed Level for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

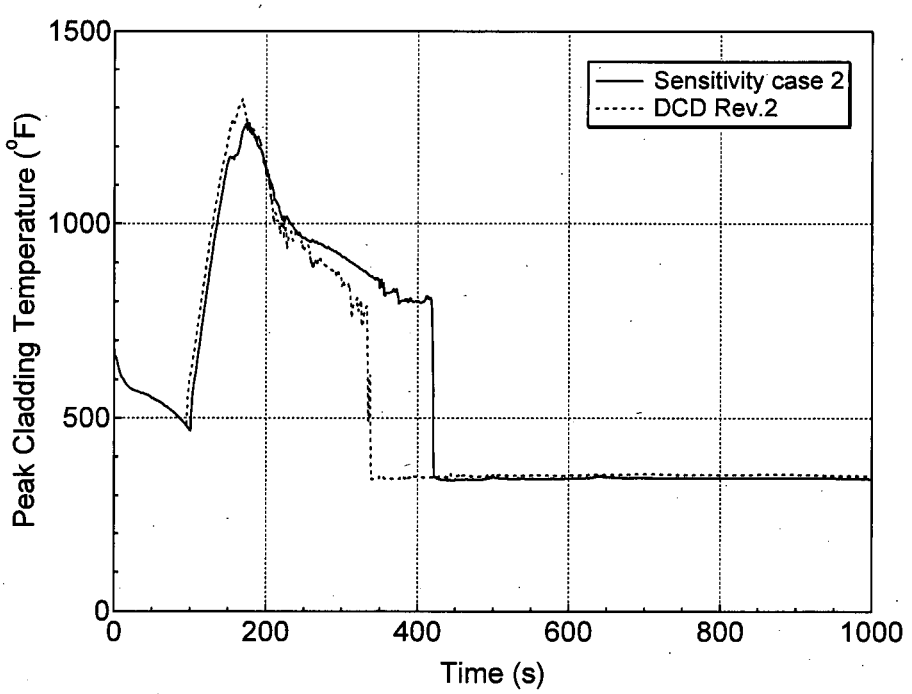

Figure RAI-15.06.05-61.30 PCT at All Elevations for Hot Rod in Hot Assembly for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

Figure RAI-15.06.05-61.31 Guide Tube Liquid Flowrate for 1-ft^2 Small Break LOCA (Sensitivity Case 2)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/15/2010

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.: 15.06.05-65

Figure 5.1.1.a-3 of MUAP-07025-P shows the discharge flow rates (liquid and vapor) for 2-inch cold-leg break. During the periods of concurrent liquid and vapor discharge through the break, large oscillations in the calculated flow rates appear.

Explain the oscillations in discharge flow, including code modeling effects and/or physical phenomena. If the oscillations are attributed to code selection changes in the critical flow model, explain in detail.

ANSWER:

The oscillations in discharge flow are caused by oscillations in void fraction at the break cell of the cold leg, which range between about 0.5 and 1.0. A description of the two-phase behavior near the break location follows. In the period of two-phase discharge flow, the steam flows toward the break from the spray nozzle between the upper head and the top of downcomer. The liquid flows towards the break from the downcomer and the pump discharge. **Figure RAI-15.06.05-65.1** shows the transients of void fraction in the upper downcomer. The mixture level is maintained **[**

]

Figure RAI-15.06.05-65.2 shows the transients of void fraction at the inlet of the reactor coolant pumps. No significant steam void is realized and no significant steam flows through the loop seal. The two-phase region is restricted in the cold legs and the upper downcomer.

Figure RAI-15.06.05-65.3 compares the mass flowrate and void fraction at the break cell **[** **]** and the discharge flowrate. The time period is from 1550 to 1650 seconds to make the oscillatory behavior clear. The mass flowrate in the cold leg is oscillating and a countercurrent flow is sometimes observed (the flow is stratified during this period). Once the liquid flows into the break cell with a high flowrate (A), the void fraction at the break cell is decreased and the discharge liquid flowrate is increased (B). Next the liquid flowrate into the break cell becomes low (C), the void fraction is increased and the discharge liquid flowrate is decreased (D). A similar oscillation continues between A'-B'-C'-D'. The Moody critical flow model is continuously applied in

the period between 1570 and 1610 seconds, which corresponds to the A-B-C-D oscillation.

For the 1-inch break case, single-phase liquid discharge occurs during the whole transient. For the 3-inch break case, the change from single-phase liquid discharge to single-phase steam discharge occurs in a relatively short period due to the loop-seal clearance and no significant two-phase discharge flow occurs.

The results presented above indicate that the oscillations in the discharge flow under the 2-inch break case are caused by the two-phase flow oscillation at the break cell and a large variation of void fraction. Although the discharge flow oscillated, no significant variation of core liquid level was observed and no heat-up was attained.

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-15.06.05-65.1 Void Fractions in Downcomer Upper Region

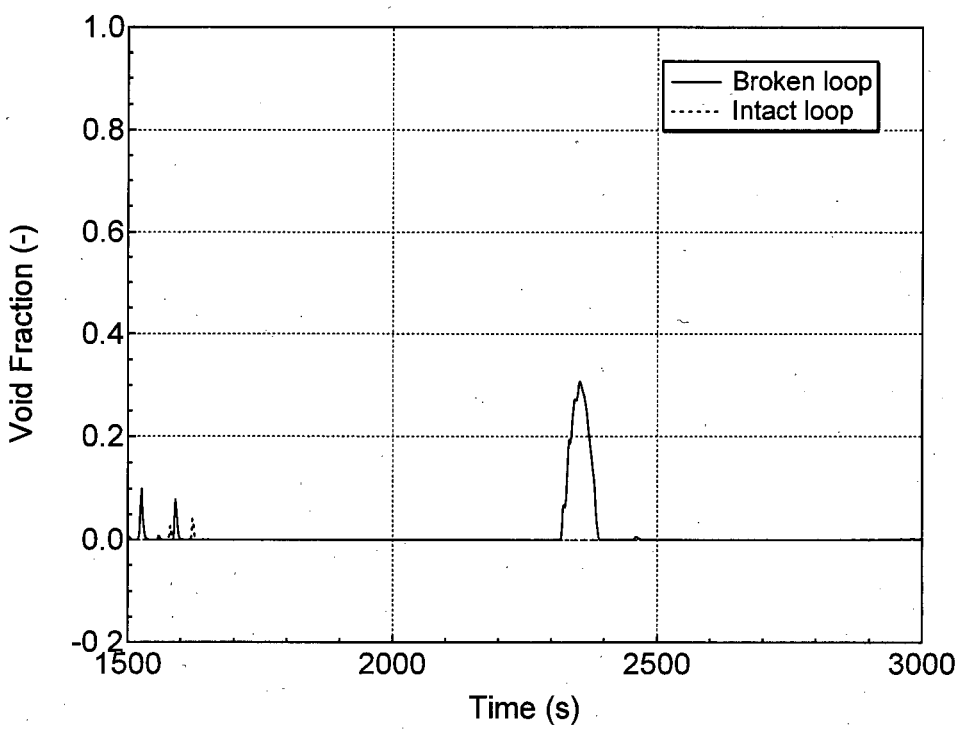

Figure RAI-15.06.05-65.2 Void Fraction at RCP Inlets

Figure RAI-15.06.05-65.3 Mass Flowrate and Void Fraction around Break Location

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/15/2010

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.: 15.06.05-71

10CFR50 Appendix K, Part II.2 requires that solution convergence be demonstrated by model noding and calculational time step studies. Sections 5.4 and 5.5 of MUAP-07025-P provide single sensitivity studies on noding and time step size specification. Traditionally, at least three points are evaluated to determine sensitivity.

Justify the adequacy of single sensitivity studies to evaluate variability with noding detail and time step size. Confirm that the time step solutions are sufficiently converged.

ANSWER:

First, the following noding sensitivity calculations have been performed and reported to the NRC to complement the code assessment analyses and the noding sensitivity analyses in References 1 and 2:

[

]

The noding scheme for US-APWR SBLOCA calculations has been determined based upon the

code assessment analyses using experimental data obtained in several integral-effects and separate-effects test facilities. Since the noding scheme is similar between the code assessment and plant calculations, it can be judged that the code assessment results (Ref.1) validate the adequacy of the plant noding scheme. The sensitivity calculations for the code assessment and US-APWR SBLOCA analyses described above, concurrently with the noding sensitivity calculations in Reference 2, indicate that the current noding scheme is appropriate and tends to predict conservative consequences in the SBLOCA analyses.

Regarding sensitivities of the specified maximum time step size, MHI judged that the current time step size applied to safety analyses is able to provide a well converged solution from the sensitivity calculations described in Reference 2. Additional sensitivity calculation results for the limiting SBLOCAs are shown in **Table RAI-15.06.05-71.1** and **Figure RAI-15.06.05-71.1**, which validates that the current time step solutions are sufficiently converged.

References:

1. Mitsubishi Heavy Industries, Ltd., Small Break LOCA Methodology for US-APWR, MUAP-07013-P (R0), July 2007.
2. Mitsubishi Heavy Industries, Ltd., Small Break LOCA Sensitivity Analyses for US-APWR, MUAP-07025-P (R0), December 2007.
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 06/11/2009, UAP-HF-09417, August 2009.
4. Mitsubishi Heavy Industries, Ltd., MHI's 2nd Part Responses to the NRC's Requests for Additional Information on Topical Report MUAP-07013-P (R0) "Small Break LOCA Methodology for US-APWR", UAP-HF-09041, February 2009.
5. 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.
6. 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 11/17/2009, UAP-HF-10003, January 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.

Table RAI-15.06.05-71.1 Sensitivity of Specified Maximum Time Step Size

Figure RAI-15.06.05-71.1 Sensitivity of Specified Maximum Time Step Size