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

September 30, 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-10263

Subject: **MHI's Responses to US-APWR DCD RAI No. 621-4947 Revision 2**

References: 1) "Request for Additional Information No. 621-4947 Revision 2, SRP Section: 19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed," dated August 30, 2010.

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 all of the RAIs that are contained within Reference 1.

As indicated in the enclosed materials, this submittal 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 Atsushi Kumaki (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 this submittal. His contact information is provided 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. Response to Request for Additional Information No. 621-4947, Revision 2 (Proprietary Version)
3. Response to Request for Additional Information No. 621-4947, Revision 2 (Non-Proprietary Version)

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

Contact Information

C. Keith Paulson, Senior Technical Manager
Mitsubishi Nuclear Energy Systems, Inc.
300 Oxford Drive, Suite 301
Monroeville, PA 15146
E-mail: ck_paulson@mnes-us.com
Telephone: (412) 373-6466

Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-10263

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 "Response to Request for Additional Information No. 621-4947, Revision 2", and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those pages contain 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 technique of the hydrogen burning analysis results related to the US-APWR severe accident analytical models developed by MHI.

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 the development of the methodology related to the analysis.

B. Loss of competitive advantage of the US-APWR created by the benefits of the 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 30th day of September 2010.

Y. Ogata

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

Enclosure 3

UAP-HF-10263
Docket No. 52-021

Response to Request for Additional Information No. 621-4947,
Revision 2

September 2010
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

09/29/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 621-4947 REVISION 2**
SRP SECTION:	**19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed**
APPLICATION SECTION:	**19**
DATE OF RAI ISSUE:	**08/30/2010**

QUESTION NO. : 19.01-2

During the staff audit of the shutdown PRA on July 8, 2010, the staff learned that POS 6 has fuel in the reactor vessel. The staff requests MHI to update Section 19.1.6.1 of the DCD and the shutdown PRA to state that fuel is in the reactor vessel during POS 6, which is currently defined as not having fuel in the reactor vessel.

ANSWER:

For low-power and shutdown PRA, the definition of POS 6 will be revised as follows:

POS 6 is the state at which there may be either no fuel in the reactor core or the fuel is partially offloaded. For refueling and examination of the fuel, the fuel is transported from the RV to the SFP during this POS. This state is excluded from the analysis because there is either no fuel in the reactor, or if the fuel is partially offloaded, there is considerable time before the reactor core is exposed given a loss of decay heat removal event. The end of POS 6 is defined as the time at which fuel is fully loaded into the reactor core.

Impact on DCD

Description of POS 6 in DCD page 19.1-103 will be revised shown in ANSWER.

In addition, the reason for model exclusion for POS 6 in Table 19.1-81 will be revised in the DCD tracking report to reflect the response to this RAI, which is shown on the next page.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

Table 19.1-81 Disposition of Plant Operating States for LPSD PRA (Sheet 1 of 2)

POS	Description	POS modeled?	Reason for model exclusion
5	Refueling cavity is filled with water (refueling)	No	This POS is the state that the refueling cavity is filled with water. Since there is large inventory water in the cavity, there would be sufficient time before core exposure and operator action will be more reliable. The CDF during this POS is considered negligible.
6	No fuel in the core, or the core is partially offloaded	No	~~This POS is the state of no fuels in the reactor core. Fuels are transported from the RV to the SFP during this POS. In the case of loss of SFP cooling, sufficient time to recover SFP cooling is available because of large coolant inventory in the pool. Therefore, this POS is excluded from the analysis.~~ This POS is the state at which there is either no fuel in the reactor core or the fuel is partially offloaded. For refueling and examination of the fuel, the fuel is transported from the RV to the spent fuel pit during this POS. This state is excluded from the analysis because there is either no fuel in the reactor, or if the fuel is partially offloaded, there is considerable time before the reactor core is exposed given a loss of decay heat removal event. The end of this POS is defined as the time at which fuel is fully loaded into the reactor core.
7	Refueling cavity is filled with water (refueling)	No	This POS is the state that the refueling cavity is filled with water. Since there is large inventory in the cavity, there would be sufficient time before core exposure and operator action will be more reliable. The CDF during this POS is considered negligible.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

09/29/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 621-4947 REVISION 2**
SRP SECTION:	**19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed**
APPLICATION SECTION:	**19**
DATE OF RAI ISSUE:	**08/30/2010**

QUESTION NO. : 19.01-3

During the staff audit of the shutdown PRA on July 8, 2010, the NRC staff needed clarification on how the RCS was drained to midloop conditions starting in POS 4-1. The staff requests MHI to update Section 19.1.6.1 of the DCD and the shutdown PRA to (1) state the size of the pressurizer vent which is open to initiate RCS draining in POS 4-1 and (2) include a description of how the pressurizer and RCS is drained in POS 4-1 to reach mid-loop conditions prior to refueling.

ANSWER:

(1)

The pressurizer vent valve is RCS-VLV-183, which is shown in Figure 5.1-2 (Sheet 2) of the US-APWR DCD Chapter 5. The size of the pressurizer spray line vent is designed to be 3/4 inch diameter. During POS 4-1, RCS draining is performed by controlling the balance between the charging and extraction flow rates of the chemical and volume control system (CVCS). The pressurizer spray line vent provides a sufficient vent path from preventing the RCS pressure to be negative compared to the containment.

Sensitivity analysis, assuming the 3/4 inch diameter pressurizer spray line vent line is kept open after loss of RHR, was performed in the response to RAI 19-45. It has been confirmed that SG reflux cooling is effective within approximately 20 hours after loss of RHR.

Therefore, piping with diameter of 3/4 inch has no impact on the RCS draining process and the SG reflux cooling.

(2)

At the beginning of POS 4-1, the RCS is full (the top of the main coolant piping). The RCS inventory and the pressurizer are drained to the mid-loop water level and kept at that water level by the charging and extraction balance of the CVCS. If the RCS water is drained below the mid-loop level, the low-pressure let-down line valves (RHS-AOV-024B and C) are automatically closed to prevent over-drain.

(The failure to automatically close the valves results in the initiating event "OVDR")

After reaching the mid-loop condition, the RCS water level is also controlled by the CVCS. When the water level is below the mid-loop level, the isolation valves are automatically closed to maintain the RCS inventory. (The failure to automatically close the valves results in the initiating event "FLML") The LPSD PRA considers that OVDR includes the FLML in the POS 4-1.

Impact on DCD
The description of POS 4 in Section 19.1.6.1 and Table 19.1-79 in the DCD will be revised as follows:

Page 19.1-103

- POS 4: RHR cooling (mid-loop operation)

  POS 4 is a mid-loop operation state with cooling by the RHRS before refueling. The POS begins at the initiation of the drain down process to the mid-loop water level, which is controlled by the CVCS. To perform the aeration of the RCS and the eddy current test on the SGs, the SG nozzle lids are installed and the upper lid on the RV is removed. The RCS water level is decreased to near the center of the reactor nozzle. Because the RCS inventory is decreasing, the possibility of the RHR pump failure due to the pump cavitations is considered. Also, the time required for loss of inventory and subsequent fuel damage is less than for other states in the event of loss of decay heat removal. At the end of POS 4, the reactor cavity is filled with water for refueling.

  POS 4, or a mid-loop operation, is further divided according to the plant states. The subdivided POSs are shown in Table 19.1-79 and Figures 19.1-13 to 19.1-15.

  - POS 4-1: This POS begins at the initiation of the drain down process from the RCS full level (top of the main coolant piping) to the mid-loop water level. The end of POS 4-1 is the time at which the SG manway covers (SG manhole lid) are opened. Decrease of the RCS inventory and maintaining water level are controlled by the CVCS. . In POS 4-1, since the RCS is closed, the reflux cooling by the SGs is available as a heat sink under the vented condition, but the gravitational injection is unavailable because the RCS is not at atmospheric pressure.
  - POS 4-2: This POS begins at the end of POS 4-1 and continues until the time that the SG nozzle lid is installed. In POS 4-2, the RCS inventory is kept at the mid-loop water level by the CVCS. Since the RCS is open, the reflux cooling by the SGs is unavailable as a heat sink, but the gravitational injection is available because the RCS is at atmospheric pressure.
  - POS 4-3: This period begins at the end of POS 4-2 and continues until the time at which the refueling cavity is filled with water. The RCS inventory is controlled by the CVCS and increased by the RWR and CS/RHR pumps. The pressurizer safety valves are removed at the beginning of the POS and the RV head is removed during the POS. In the case of POS 4-3, since the RCS is isolated from the SGs, the decay heat removal by the SGs is unavailable.

Table 19.1-79 Subdivided State of POS 4 (Mid-Loop Operation) for LPSD PRA

<table>
<tr><td></td><td colspan="4">Open S/G manhole lid ↓ Install S/G nozzle lid ↓</td><td>Remarks</td></tr>
<tr><td>RCS water level</td><td>RCS full</td><td colspan="2">Mid-loop (nozzle center)</td><td>Reactor cavity full</td><td></td></tr>
<tr><td>POS</td><td>(POS4-1)</td><td>(POS4-2)</td><td colspan="2">(POS4-3)</td><td></td></tr>
<tr><td>RCS conditions</td><td>RCS close</td><td>RCS open</td><td colspan="2">RCS open
SG Isolated</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="6">Mitigating systems</td></tr>
<tr><td>SG and secondary systems</td><td>×</td><td>N/A</td><td colspan="2">N/A</td><td></td></tr>
<tr><td>Gravitational injection</td><td>N/A</td><td>×</td><td colspan="2">N/A</td><td></td></tr>
<tr><td colspan="6">Initiating events</td></tr>
<tr><td>Over-drain</td><td>×</td><td>N/A</td><td colspan="2">N/A</td><td rowspan="2">Over-drain includes the failure to maintain water level in POS 4-1.</td></tr>
<tr><td>Failure to maintain water level</td><td>N/A</td><td>×</td><td colspan="2">×</td></tr>
</table>

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

09/29/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 621-4947 REVISION 2**
SRP SECTION:	**19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed**
APPLICATION SECTION:	**19**
DATE OF RAI ISSUE:	**08/30/2010**

QUESTION NO. : 19.01-4
Based on the NRC staff audit of the shutdown PRA on July 8, 2010, the staff requests the applicant to document in Section 19.1.6.1 of the DCD and the shutdown PRA whether gravity injection can be credited in POS 8-1 and 8-2 (midloop following refueling) since a safety valve is removed. If gravity injection can be credited, please explain why.

ANSWER:

Gravity injection will not be considered in POS 8-1 even if the RV head is removed or the pressurizer safety valves are removed. On the other hand, the gravity injection will be expected as a mitigation function in POS 8-2 where the SG manhole is open and the SG nozzle lid is removed. The basis is shown below:

POS 8-1 is considered to be the most severe condition as indicated by the following:

(1) Mid-loop operation, where the RCS inventory is the lowest, has the minimum allowable time until the uncovering of the reactor core.
(2) POS 8-1 has the longest duration time (55.5 hr) in all POSs modeled in the LPSD PRA.
(3) POS 8-1 has the maximum number of initiating events.
(4) POS 8-1 is one of the POSs that have the minimum number of mitigation systems.
(5) The decay heat is still high.

The RV head is still in the removed condition at the beginning of POS 8-1 and is installed during this POS. The gravity injection can be available when the RV head is off; however, the duration of RV head off is assumed to be very short (a few hours) compared with the entire duration of POS 8-1 (55.5 hr). Therefore, this configuration has not been distinguished as being conservative.

The pressurizer safety valves (PSVs) must be removed when the RV head is installed during mid-loop operation without any venting means. According to the previous studies in Japan, the gravity injection has not been considered to be effective for the prevention of core uncovering when only PSVs are removed for venting. This is because there is a possibility that the primary side is pressurized by the water level of the pressurizer and that there is a pressure loss due to the piping of PSVs before and after the execution of the gravity injection. For the US-APWR, which might have the same condition, the validity of gravity injection has to be confirmed by the thermal-hydraulic analysis. MHI has judged that the current PSA adequately captures the risk profile because (1) the current PSA result without gravity injection during POS 8-1 is not excessively conservative and (2) the reliability assurance program (RAP) includes equipment related to the gravity injection as an important SSC.

In conclusion, MHI judges that POS 8-1 is the bounding case for the LPSD PRA. Therefore, the gravity injection is conservatively assumed to be unavailable in POS 8-1 due to the short duration and the uncertainty of its validity.

Impact on DCD
The description that gravity injection cannot be credited in POSs 4-3 and 8-1 will be inserted in DCD Section 19.1.6.1 in the next update tracking report as shown below:

Page 19.1-109

- GI: Gravity injection

  Gravity injection from the SFP to the RCS is expected if the other mitigation systems fail. The RCS must be at atmospheric pressure. In order for gravity injection to be initiated, it is necessary to operate valves in the injection line and to supply RWSP water to the SFP using the refueling water recirculation pumps. This function is unavailable if the RCS is pressurized or if the SG nozzle lid is installed to isolate the SG.

Impact on COLA
There is no impact on COLA.

Impact on PRA
There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

09/29/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 621-4947 REVISION 2**
SRP SECTION:	**19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed**
APPLICATION SECTION:	**19**
DATE OF RAI ISSUE:	**08/30/2010**

QUESTION NO. : 19.01-5

During the NRC staff audit of the shutdown PRA on July 8, 2010, the staff learned that the applicant plans to refill the RCS using vacuum refill in POS 8-3. The staff requests MHI to update Section 19.1.6.1 of the DCD and the shutdown PRA for internal and external events to state that the applicant plans to refill the RCS using vacuum refill in POS 8-3. The applicant needs to summarize this process in the shutdown PRA and the DCD, including (1) how the RCS will be configured for vacuum refill and (2) how the RCS will be configured if the RHR function is lost.

ANSWER:

(1)

POS 8-3 is the state where the SG manhole is closed and the SG nozzle lid is removed. The following are the steps to vacuum refill the RCS:

(1) Air is removed from the RCS by the pressurizer auxiliary spray and temporary vacuum pump.
(2) The RCS inventory is gradually increased.
(3) Air in the SG U-tubes is transferred to the top of the RV by operating the RCPs.
(4) Air is removed from the RV head by the temporary vacuum pump, which results in RV refill.

(2)

In POS 8-3 during the mid-loop operation, three RHR loops shall be operable and two RHR loops shall be in operation in accordance with the technical specification, which is referred from LCO 3.4.8 of DCD Chapter 16. If the RHR function is partially lost (e.g., loss of two CS/RHR pumps), the other two CS/RHR pumps are available to the RHR operation. If a total loss of RHR function occurs in POS 8-3, the SG reflux cooling is effective to prevent core damage. In addition, mitigation systems such as safety injection and charging injection can be used to prevent the core damage.

Impact on DCD

The description in Section 19.1.6.1 and Table 19.1-80 in the DCD will be revised as follows:

Pages 19.1-103 and 104

- POS 8: RHR cooling (mid-loop operation after refueling)

    POS 8 is a mid-loop state with cooling by the RHRS after refueling. The POS begins at the initiation of the drain down process from the cavity full to the mid-loop water level. The RCS is drained by the CS/RHR pumps, RWR pumps, and CVCS. In order to install the upper lid on the RV and to remove the SG nozzle lids, the RCS water level is decreased to near the center of the reactor nozzle. Because the RCS inventory is decreased, the possibility of RHR pump failure by cavitation is considered. Also, the time to act to avoid reactor core damage in this state is less than in other states because the RCS inventory is decreased. At the end of POS 8, the water level in the RCS is at the top of the main coolant piping.

    POS 8, or a mid-loop operation, is further divided according to plant states. The subdivided POSs are shown in Table 19.1-80 and Figures 19.1-13 to 19.1-15.

    - POS 8-1: This POS begins at the initiation of the drain down process from the cavity full level to the mid-loop water level. The end of POS 8-1 is the time at which the SG nozzle lid is removed. The RV head is removed at the beginning of this POS and the pressurizer safety valves are removed during this POS. The RCS is drained by the CS/RHR pumps and the RWR pump at the early stage of this POS. After the installation of the RV head, the RCS inventory is drained or controlled by the CVCS. In the case of POS 8-1, since the RCS is isolated from the SGs, decay heat removal by the SGs is unavailable.
    - POS 8-2: This POS begins at the end of POS 8-1 and continues until the time that the SG manhole lid is closed. In POS 8-2, the RCS inventory is kept at the mid-loop water level by the CVCS. Since the RCS is open, the reflux cooling by SGs is unavailable as a heat sink, but gravity injection is available because the RCS is at atmospheric pressure.
    - POS 8-3: This period begins at the end of POS 8-2 and continues until the time at which the RCS inventory is increased up to the top of the main coolant piping. The RCS inventory is controlled by the CVCS. In POS 8-3, air in the RCS is removed and transferred from the SG to the top of the RV head by operating the RCPs. Removal of the air from the RCS results in vacuum refill of the RCS. In POS 8-3, since the RCS is closed, reflux cooling by the SGs is available as a heat sink.

Table 19.1-80 Subdivided State of POS 8 (Mid-Loop Operation) for LPSD PRA

	Open S/G manhole lid ↓	Install S/G nozzle lid ↓		Remarks
RCS water level	Reactor cavity full	Mid-loop (nozzle center)	RCS Full	
POS	(POS8-1)	(POS8-2)	(POS8-3)	
RCS conditions	RCS open SG isolated	RCS open	RCS closed	
Mitigating systems				
SG and secondary systems	N/A	N/A	×	
Gravitational injection	N/A	×	N/A	
Initiating events				
Over-drain	×	N/A	N/A	Over-drain includes failure to maintain water level in POS 8-1.
Failure to maintain water level	N/A	×	×	

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

09/29/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 621-4947 REVISION 2**
SRP SECTION:	**19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed**
APPLICATION SECTION:	**19**
DATE OF RAI ISSUE:	**08/30/2010**

QUESTION NO. : 19.01-6

As discussed at the NRC staff audit of the shutdown PRA on July 8, 2010, the staff is requesting MHI to update Section 19.1.6.1 of the DCD and the shutdown PRA to include the revised times for RCS boiling and the revised time to core damage, assuming an extended loss of the RHR function for POSs 4-1, 4-2, 4-3, 8-1, 8-2, and 8-3 given that POS 4 and POS 8 will be redefined in response to RAI 19-441.

ANSWER:

Times for RCS boiling and to core damage were re-assessed only in POS 8-1, assuming the most severe condition in terms of time before core damage. The re-estimated times were shorter than those of the previous case. Shorter time to core damage results in higher failure probability of successful offsite power recovery, and this change will be reflected in the PRA. On the other hand, the analysis conditions for POSs other than POS 8-1 have been confirmed to be correct, and the times for RCS boiling and to core damage will be unchanged. Thus, the total CDF was re-estimated to be 2.3E-07/RY, which is an increase of approximately 5% from the base case. The LPSD PRA model will be revised to reflect the response to this RAI. The basis is shown below:

The current analysis has assumed that the RV head is removed and the SG nozzle lid is installed in POS 8-1. The RCS coolant is vaporized by the decay heat and released from top of the RV, resulting in the decrease in the RCS inventory. On the other hand, the analysis in POS 8-2 has assumed that the RV head is installed and the SG nozzle lid is removed. The boiling in the core after loss of RHR causes an increase in the RCS boiled-up water level. The coolant in the liquid phase flows out from the hot leg via the SG manhole because of the elevation of the water level. After that, the RCS inventory decreases gradually due to the boiling. Although the decay heat in POS 8-2 is lower than in POS 8-1, the core is uncovered earlier in POS 8-2 than in POS 8-1 for the above reason.

The RV head is removed at the beginning of POS 8-1 and installation is started. Thus, the assumption that the RV head is kept open during POS 8-1 is less conservative. Therefore, the time until the uncovering of the reactor core is re-assessed under the more severe condition where the RV head is constantly being installed.

MAAP analysis is first carried out in order to estimate time until the uncovering of reactor core when the RV head is constantly being installed in POS 8-1. The analysis condition (i.e., plant configuration) is the same as that in POS 8-2 and the decay heat in POS 8-1 is larger than that in POS 8-2. The re-estimated time to the uncovering of the core is approximately 3.7 hours. Table 19.01.6-1 (proprietary information) shows the plant configuration and the times for core uncovered, cladding rupture and core melt for each POS modeled in the LPSD PRA, which includes the results revised from Table 19.1-69-1 in the response to RAI #39-548 (Question No. 19.69).

The PRA conservatively assumes that the allowable time until the uncovering of the reactor core is 3 hours. The failure probability of offsite power recovery is taken as 1.7E-01, which is referred from Table 4-1 in NUREG/CR-6890 Vol.1. Using the failure probability, the estimated CDF of each initiating event for each POS is summarized in Table 19.01.6-2. The total CDF is estimated to be 2.3E-07/RY, which is an increase of approximately 5% from the base case CDF (2.2E-07/RY). In the next DCD update tracking report, the failure probability of offsite power recovery in POS 8-1 will be revised.

<u>Impact on DCD</u>

The description of offsite power recovery in DCD Section 19.1.6.1 page 19.1-113 will be revised as follows:

<u>Page 19.1-113</u>

- AC: Offsite power recovery

  The recovery of the LOOP with an allowable time is considered. The allowable time is assumed to be ~~1 hour~~ <u>three hours</u>, based on time until the uncovering of reactor core by MAAP analysis. The probability that the LOOP duration exceeds ~~six~~ <u>three</u> hours is taken as ~~0.91~~ <u>0.17</u> from Reference 19.1-41.

The LPSD PRA model and the results will be updated in the DCD tracking report.

<u>Impact on COLA</u>

There is no impact on COLA.

<u>Impact on PRA</u>

The failure probability of offsite power recovery in POS 8-1 will be revised to reflect the discussion.

Proprietary

Table 19.01.6-2 Core Damage Frequency of Each Initiating Event for Each POS

IE	Event description	POS3[2]	POS4-1[2]	POS4-2[2]	POS4-3[2]	POS8-1[1]	POS8-2[2]	POS8-3[2]	POS9[2]	POS11[2]	Total
LOCA	Loss of coolant accident	1.2E-08	1.2E-08	1.1E-08	2.2E-08	2.2E-08	1.1E-08	1.2E-08	1.2E-08	1.2E-08	1.3E-07
OVDR	Loss of RHRS due to over-drain	N/A	1.1E-09	N/A	N/A	1.8E-09	N/A	N/A	N/A	N/A	2.9E-09
FLML	Loss of RHRS caused by failing to maintain water level	N/A	N/A	3.2E-10	3.0E-09	N/A	3.2E-10	4.4E-10	N/A	N/A	4.1E-09
LORH	Loss of RHRS caused by other failures	2.2E-11	6.7E-10	2.9E-10	2.9E-10	3.5E-09	2.9E-10	1.1E-10	9.8E-11	4.3E-10	5.8E-09
LOCS	Loss of CCW/essential service water	2.9E-10	9.0E-10	5.6E-11	1.4E-10	7.5E-09	1.1E-10	5.2E-10	4.8E-10	5.5E-09	1.5E-08
LOOP	Loss of offsite power	9.1E-10	1.0E-08	6.4E-09	4.3E-09	~~2.5E-08~~ 3.0E-08	3.8E-09	2.5E-09	2.2E-09	9.5E-09	~~6.5E-08~~ 7.0E-08
TOTAL		1.4E-08	2.5E-08	1.8E-08	3.0E-08	~~6.0E-08~~ 6.6E-08	1.6E-08	1.6E-08	1.5E-08	2.8E-08	~~2.2E-07~~ 2.3E-07

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

09/29/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 621-4947 REVISION 2**
SRP SECTION:	**19.01 – Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed**
APPLICATION SECTION:	**19**
DATE OF RAI ISSUE:	**08/30/2010**

QUESTION NO. : 19.01-7

As discussed at the NRC staff audit of the shutdown PRA on July 8, 2010, the staff requests MHI to update the shutdown PRA and the DCD to provide a discussion on how the min-max seismic margins approach was applied to shutdown. The staff is requesting the applicant to update the shutdown PRA to include the seismic cutsets and the sequence HCLPF capacities using the min-max method. The staff also requests MHI to update the shutdown PRA to include the dominant mixed cutsets containing seismic failures and random failures.

ANSWER:

Core damage sequences of LPSD are simple. For example, as shown in Figure 1 (DCD Revision 2 Figure 19.1-18 "Loss of RHRS caused by Other Failures Event Tree"), if any one of the mitigating systems is available, the event will not result in core damage.

On the min-max approach, plant level HCLPF is evaluated considering HCLPFs of initiating events and HCLPFs of event sequences. For the LPSD Seismic SMA, a simplified assumption is made which is that any initiating event will occur as a result of a seismic event.

As described in the response to RAI #528-4023 (RAI19-422) and shown in Table 1, if the safety injection (SI) system is available, it does not result in core damage for all POSs and initiating events during LPSD.

Seismic cutsets for the SI system are described in Chapter 24 of Revision 1 of the US-APWR PRA report (Attachment 24C.2 System HCLPF Calculations, Table 2-2, 2-4 and 2-6). The dominant seismic cutsets for the SI system are as follows:

No.	Seismic Cutsets (Description)	:HCLPF
1.	SE-EPSDLFFGTABCD (Emergency Gas Turbine Generators GTA, B, C, D)	: 0.50g
2.	SE-HPIPMFFSIPABCD (Safety Injection Pumps SIPA, B, C, D)	: 0.62g
3.	SE-EPSEPFFBCPABCD (Battery Charger Panels BCP-A, B, C, D)	: 0.75g
4.	SE-EPSEPFFIBDABCD (Instrument Power Distribution Panels IBD-A, B, C, D)	: 0.75g
5.	SE-EPSIVFFINVABCD Inverters INVA, B, C, D (Instrument Power Panels)	: 0.75g

Using the min-max method, the HCLPF for the SI system is 0.50g.

Key random failures/human errors during LPSD are reviewed. For POS 8-1 and the initiating event LORH, only the SI system is expected to be functional after a seismic event, as noted on Figure 1.

Dominant random failures/human errors that lead to SI system failure are as follows:

No.	Dominant random failures/human errors (Description)	:Prob.
1.	HPIOO02S (Operators fail to start standby SI pumps)	:4.9E-3
2.	EPSCF3DLLRDG-ALL (GTG A,B,C fail to load and run after 1hr. operation(CCF)*) (*: GTG-D is out of service during POS 8-1)	:1.1E-3

The dominant mixed cutsets are the combinations of seismic failures of non seismic category 1 SSCs and random failures/human errors.

Opening the pressurizer depressurization valve (SDV) in conjunction with SI system operation will be needed for POSs where the RCS is closed, such as POS 3. The need for opening the SDV will not affect the HCLPF sequence since the HCLPF of the SDV is 0.8g, which is greater than the HCLPF for the SI system.

SSCs for LPSD mitigation systems are involved in the list of SSCs for at-power SMA and the HCLPFs of the SSCs are not less than 0.5g.

Only during the case of loss of offsite power or loss of CCW events by a seismic event will mitigation systems possibly be unavailable. However, HCLPFs of Class 1E gas turbine generators (GTGs) and CCWS are also greater than the SI system HCLPF of 0.5g.

Therefore, plant level HCLPF for LPSD will not be less than 0.5g (RLE).

Impact on DCD

DCD will be updated as the attached Marked-up.

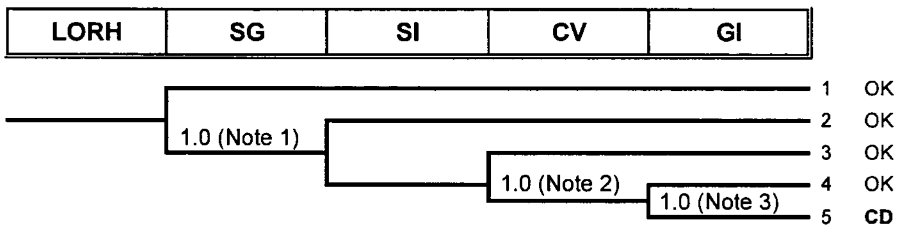
Impact on COLA

There is no impact on COLA.

Impact on PRA

The additional discussion will be reflected in Chapter 24 of the PRA Report MUAP-07030(R2).

(POS8-1)



Event	Description
LORH	Loss of RHRS caused by other failures
SG	: Decay heat removed from the RCS via SGs
SI	: High head injection
CV	: Injection by the CVCS
GI	: Gravitational injection

Figure 1 Loss of RHRS caused by Seismic Event Tree

(From DCD Revision 2 Figure 19.1-18)

Note 1 - SG is not available during POS 8-1.
Note 2 - CV is assumed to be non-functional due to a seismic event since the refueling water auxiliary tank is not in Seismic Category I.
Note 3 - GI is assumed to be non-functional due to a seismic event since the refueling water recirculation pumps to provide boric acid water from RWSP to the spent fuel pits are not in Seismic Category I.

Identifier	Initiating Event Description	Mitigating Systems							POS
		LO	MC	RH	SG	SI	CV	GI	
OVDR	Loss of RHRS due to over-drain	X	(1)	(2)	(3)	X	(4)		POS 4-1 and POS 8-1
FLML	Loss of RHRS Caused by failing to maintain water level	X	(1)	(2)	(3)	X	(4)	(5)	POS 4 and POS 8
LOCA	Loss of coolant accident	X	(1)	(2)	(3)	X	(4)	(5)	all POSs
LORH	Loss of RHRS Caused by Other Failures				(3)	X	(4)	(5)	all POSs
LOCS	Loss of CCWS/ESWS (7)							(5)	all POSs
LOSP	Loss of Offsite Power			X (6)	(3) (6)	X (6)	(4) (6)	(5) (6)	all POSs

(Notes)
X: The system would be functional during and after a seismic event.
(1) MC is assumed to be non-functional due to a seismic event since the refueling water auxiliary tank is not Seismic Category I.
(2) Failure of MC would lead to loss of RH.
(3) SG is not available during POS4-2, 4-3, 8-1and 8-2.
(4) CV is assumed to be non-functional due to a seismic event since the refueling water auxiliary tank is not Seismic Category I.
(5) GI is assumed to be non-functional due to a seismic event since the refueling water recirculation pumps to provide boric water from RWSP to the spent fuel pits are not Seismic Category I.
(6) In order to operate mitigating systems, GT/G is required to start and run after loss of offsite power.
(7) The plant has a seismic margin for seismically induced loss of CCWS/ESWS since the seismic capacity of CCWS/ESWS is higher than review level earthquake.

(Acronyms)
LO (Isolation of Letdown Line), MC (RCS Makeup by Charging Pumps), RH (Decay Heat Removed from the RCS by the RHRS on Standby), SG(Decay Heat Removed from the RCS via SGs), SI (Safety Injection), CV (Injection by Chemical and Volume Control System), GI (Gravitational Injection)

Table 1 Initiating Events and Mitigating Systems during LPSD

19.1.6.3.1 LPSD Seismic at LPSD

For seismic considerations, SSCs for LPSD have been involved in Subsection "19.1.5.1 Seismic Risk Evaluation" and confirmed that the HCLPFs are greater than or equal to RLE.

On the min-max approach, plant level HCLPF is evaluated considering HCLPFs of initiating events and HCLPFs of event sequences. For the LPSD Seismic SMA, a simplified assumption is made which is that any initiating event will occur as a result of a seismic event.

As shown in Table 19.1-120, if the safety injection (SI) system is available, it does not result in core damage for all POSs and initiating events during LPSD.

The dominant seismic cutsets for the SI system are as follows:

No.	Seismic Cutsets (Description)	:HCLPF
1.	SE-EPSDLFFGTABCD (Emergency Gas Turbine Generators GTA, B, C, D) : 0.50g	
2.	SE-HPIPMFFSIPABCD (Safety Injection Pumps SIPA, B, C, D)	: 0.62g
3.	SE-EPSEPFFBCPABCD (Battery Charger Panels BCP-A, B, C, D)	: 0.75g
4.	SE-EPSEPFFIBDABCD (Instrument Power Distribution Panels IBD-A, B, C, D)	: 0.75g
5.	SE-EPSIVFFINVABCD Inverters INVA, B, C, D (Instrument Power Panels)	: 0.75g

Using the min-max method, the HCLPF for SI system is 0.50g.

Key random failures/human errors during LPSD are reviewed. For POS 8-1 and the initiating event LORH, only the SI system is expected to be functional after a seismic event, as noted in Figure 19.1-22.

Dominant random failures/human errors that lead to SI system failure are as follows:

No.	Dominant random failures/human errors (Description)	:Prob.
1.	HPIOO02S (Operators fail to start standby SI pumps)	:4.9E-3
2.	EPSCF3DLLRDG-ALL (GTG A,B,C fail to load and run after 1hr operation(CCF)*) (*: GTG-D is out of service during POS 8-1)	:1.1E-3

The dominant mixed cutsets are the combinations of seismic failures of non seismic category 1 SSCs and random failures/human errors.

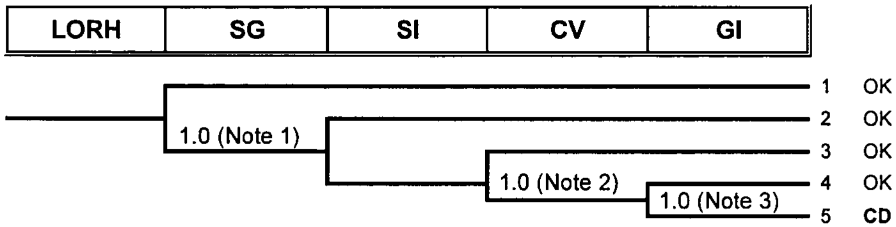
Opening the pressurizer depressurization valve (SDV) in conjunction with SI system operation will be needed for POSs where the RCS is closed, such as POS 3. The need for opening the SDV will not affect the sequence HCLPF since the HCLPF of the SDV is 0.8g, which is greater than the HCLPF for the SI system.

SSCs for LPSD mitigation systems are involved in the list of SSCs for at-power SMA and the HCLPFs of the SSCs are not less than 0.5g.

Only during the case of loss of offsite power or loss of CCW events by a seismic event will mitigation systems possibly be unavailable. However, HCLPFs of Class 1E gas turbine generators (GTGs) and the CCWS are also greater than the SI system HCLPF of 0.5g.

Therefore, plant level HCLPF for LPSD will not be less than RLE.

(POS8-1)



Event	Description
LORH	Loss of RHRS caused by other failures
SG	: Decay heat removed from the RCS via SGs
SI	: High head injection
CV	: Injection by the CVCS
GI	: Gravitational injection

Note 1 - SG is not available during POS 8-1.

Note 2 - CV is assumed to be non-functional due to a seismic event since the refueling water auxiliary tank is not in Seismic Category I.

Note 3 - GI is assumed to be non-functional due to a seismic event since the refueling water recirculation pumps to provide boric acid water from RWSP to the spent fuel pits are not in Seismic Category I.

Figure 19.1-22 Loss of RHRS caused by Seismic Event Tree

Identifier	Initiating Event Description	Mitigating Systems							POS
		LO	MC	RH	SG	SI	CV	GI	
OVDR	Loss of RHRS due to over-drain	X	(1)	(2)	(3)	X	(4)		POS 4-1 and POS 8-1
FLML	Loss of RHRS Caused by failing to maintain water level	X	(1)	(2)	(3)	X	(4)	(5)	POS 4 and POS 8
LOCA	Loss of coolant accident	X	(1)	(2)	(3)	X	(4)	(5)	all POSs
LORH	Loss of RHRS Caused by Other Failures				(3)	X	(4)	(5)	all POSs
LOCS	Loss of CCWS/ESWS (7)							(5)	all POSs
LOSP	Loss of Offsite Power			X (6)	(3) (6)	X (6)	(4) (6)	(5) (6)	all POSs

(Notes)
X: The system would be functional during and after a seismic event.
(1) MC is assumed to be non-functional due to a seismic event since the refueling water auxiliary tank is not Seismic Category I.
(2) Failure of MC would lead to loss of RH.
(3) SG is not available during POS4-2, 4-3, 8-1and 8-2.
(4) CV is assumed to be non-functional due to a seismic event since the refueling water auxiliary tank is not Seismic Category I.
(5) GI is assumed to be non-functional due to a seismic event since the refueling water recirculation pumps to provide boric water from RWSP to the spent fuel pits are not Seismic Category I.
(6) In order to operate mitigating systems, GT/G is required to start and run after loss of offsite power.
(7) The plant has a seismic margin for seismically induced loss of CCWS/ESWS since the seismic capacity of CCWS/ESWS is higher than review level earthquake.

(Acronyms)
LO (Isolation of Letdown Line), MC (RCS Makeup by Charging Pumps), RH (Decay Heat Removed from the RCS by the RHRS on Standby), SG(Decay Heat Removed from the RCS via SGs), SI (Safety Injection), CV (Injection by Chemical and Volume Control System), GI (Gravitational Injection)

Table 19.1-120 Initiating Events and Mitigating Systems during LPSD