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December 27 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-10344

Subject: **MHI's Responses to US-APWR DCD RAI No.668-5180 Revision 2 (SRP 19.0)**

References: 1) "Request for Additional Information No. 668-5180 Revision 2, SRP Section: 19.01 – determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed," dated November 29, 2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 668-5180 Revision 2".

Enclosed are the responses to all of the RAIs that are contained within Reference 1.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is below.

Sincerely,

Y. Ogata

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

Enclosure:

1. Responses to Request for Additional Information No. 668-5180 Revision 2

D081
NRO

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

<u>Contact Information</u>

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Enclosure 1

UAP-HF-10344
Docket Number 52-021

Responses to Request for Additional Information No.668-5180
Revision 2

December, 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 668-5180 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:	**11/29/2010**

QUESTION NO. : 19.01-9

On page 19.1-964 of the US-APWR DCD, Revision 2, Key Assumption 9, it states, "nitrogen will not be injected in the SG tubes to speed draining in the US-APWR design. The SG tubes will be filled with air during midloop operation". In response to RAI 19.01-3, MHI stated that the pressurizer vent valve, which is 3/4 inch in diameter, provides a sufficient vath path from preventing the RCS pressure to be negative compared to containment during RCS draining. The staff requests MHI to provide an analysis to show that RCS draining from pressurizer full to midloop conditions (assuming draining by CVCS and a RCS vent of 3/4 inch in diameter) can be performed in the timeframe that MHI assumed.

ANSWER:

The results obtained from a simple calculation shows the pressurizer spray vent path is sufficient to support draindown in the timeframe modeled for RCS draining in the LPSD PRA.

The time for RCS draining from the pressurizer-full water level to the mid-loop water level (the center of the main coolant piping[MCP] [NOTE1]) was estimated from the RCS water volume drained when evolving from POS 3 to POS 4-1 (the center of the MCP) and the RCS drain rate anticipated in the US-APWR operation. The water volume drained when evolving from RCS full to mid-loop water level is 8040 ft^3. With a draindown flow rate of 88 gpm (706 ft^3/h) [NOTE2], the duration of RCS drain is estimated to be approximately 12 hours, which is within the timeframe considered in the LPSD PRA[NOTE3].

The possibility of negative RCS pressure caused by the limited size of RCS vent path during draindown does not restrict draindown flow rate because draindown via the low pressure letdown line is achieved by the CS/RHR pump. Even if the pressure in the pressurizer becomes negative compared to containment pressure, drandown ability will not significantly degrade. It should also be noted that the US-APWR design allows vacuum venting, and the equipment in the RCS is designed to allow negative RCS pressure during the RCS draining process.

Based on the above discussion, it is anticipated that RCS draining to mid-loop (the center of the MCP) can be performed within the timeframe considered in LPSD PRA.

NOTE 1:
While it is assumed in the LPSD PRA that the RCS water level is at the center of MCP, the RCS water level is actually maintained above the center of MCP during POS 4-1.. .

NOTE 2:
The drain rate of 88 gpm was chosen as a reasonable value based on experience of chemical and volume control system (CVCS) letdown in US operating plants and the capability of the CVCS letdown in the US-APWR design. As stated in the response, negative pressure in the pressurizer compared to the containment that can potentially occur due to the relatively small RCS vent path size, does not restrict the ability of CVCS letdown.

NOTE 3:
The duration of each POS considered in the LPSD PRA is summarized in Table 19.01.09-1, which also shows a comparison of the duration for each POS between experiences of US and US-APWR shutdown schedules assumed in DCD Rev. 2 LPSD risk assessment. The duration is changed from DCD Rev. 2 (of 14 hours) to reflect the response to Question No.19.493 of RAI #669-5219 (of 36 hours), and the new duration will be used in the LPSD PRA model reported in DCD Rev. 3. The boxed value in Table 19.01.09-1 shows the duration of 14 hours for RCS draining considered in the current LPSD PRA.

Reference

1. Low Power and Shutdown Risk Assessment Benchmarking Study, EPRI 1003465, Washington, DC, December 2002.

Impact on DCD

There is no impact on DCD.

Impact on R-COLA and S-COLA

There is no impact on R-COLA and S-COLA..

Impact on PRA

There is no impact on PRA.

Table 19.01.09-1 Comparison of Duration for Each POS (Sheet 1 of 2)

POS		Description: Plant State	Description: From	Description: To	EPRI TR 1003465: Group of plant operating states	EPRI TR 1003465: Interpretation of EPRI	EPRI TR 1003465: Duration [Hr]	Duration used in PRA [Hr]: US Operational PWR Experience (Base Case)		Duration used in PRA [Hr]: US-APWR Shutdown Schdule (Used in DCD rev.2)		Remarks
1		Low power operation	Power operation	Insertion of control rods	Normal Pressurizer Level, Early	The "normal pressurizer level, early" is assumed to cover the transition from normal power operation to RHR connection.	12	3		2		Not modeled in LPSD PRA
2		Hot standby (SG cooling without RHR cooling)	Insertion of control rods	RHR connection (RCS temperature reaches 350F)				9		8		Not modeled in LPSD PRA
3		RHR operation (RCS is filled with coolant)	RHR connection (RCS temperature reaches 350F)	Initiation of RCS draining	Pressurizer Solid, Early	The "pressurizer solid" is assumed to cover the state from RHR connection to initiation of RCS draining.	24	24		2		
4-1	A	Mid-loop operation with RHR cooling (from initiation of draining the RCS to opening the SG manhole)	Initiation of RCS draining	RCS mid-loop level	Midloop, Early, No Vent	The "midloop, early, no vent" is assumed to cover the state from initiation of RCS draining to installation of the SG nozzle lid because the RCS level is kept below the top of the main coolant pipe.	36	24	14	39	29	
	B		RCS mid-loop level	Opening the SG manhole					10		10	
4-2		Mid-loop operation with RHR cooling (from opening the SG manhole to installation of the SG nozzle lid)	Opening the SG manhole	Installation of SG nozzle lid				12		12		
4-3	A	Mid-loop operation with RHR cooling (from installation of the SG nozzle lid to cavity full)	Installation of SG nozzle lid	Initiation of RCS supplying	6" below RCS flange, Early, No Vent	The "6 below RCS flange early no vent" is assumed to cover the state from the installation of the SG nozzle lid to RCS flange level because (1) the RCS level is kept below flange level and (2) there is no vent in this configuration. (The RV head is removed after POS 4-3 D.)	36	108	36	122	39	
	B		Initiation of RCS supplying	RCS flange level								
	C		RCS flange level	RCS flange level								
	D		RCS flange level	RCS flange level	Before Fuel Movement Ends	The "before fuel movement ends" is assumed to cover the state from the RCS flange level to the time that the fuel movement ends because this configuration should not be included in the previous POS due to the venting with the RV head off.	72					
	E		RCS flange level	Cavity full								
5		Fuel offload	Initiation of fuel offload	Fuel movement ends					72		83	Not modeled in LPSD PRA
6		No fuel or partial offload	Fuel movement ends	Initiation of fuel load	Not mentioned in EPRI report.		168	240	168	184	108	Not modeled in LPSD PRA
7		Fuel load	Initiation of fuel load	Fuel movement ends					72		76	Not modeled in LPSD PRA

Table 19.01.09-1 Comparison of Duration for Each POS (Sheet 2 of 2)

POS		Description			EPRI TR 1003465			Duration used in PRA [Hr]				Remarks
		Plant State	From	To	Group of plant operating states	Interpretation of EPRI	Duration [Hr]	US Operational PWR Experience (Base Case)		US-APWR Shutdown Schdule (Used in DCD rev.2)		
8-1	A	Mid-loop operation with RHR cooling (from cavity full to removal of the SG nozzle lid)	Cavity full	RCS flange level	After Fuel Movement Ends	The "after fuel movement ends" is assumed to cover the state from the cavity full to the RCS flange level.	72	60	8	56	8	
	B		RCS flange level	RCS flange level	6" below RCS flange, Late, Vented	The "6 below RCS flange late vented" is assumed to cover the state from the RCS flange level to the removal of the SG nozzle lid because (1) the RCS level is kept below the flange level and (2) the RV head is off or the pressurizer safety valves are removed during the installation of the RV head. In addition, after the removal of the SG nozzle lid, the SG manhole is open.	72					
	C		RCS flange level	RCS flange level								
	D		RCS flange level	RCS mid-loop level								
	E		RCS mid-loop level	Removal of the SG nozzle lid					52		48	
8-2		Mid-loop operation with RHR cooling (from removal of the SG nozzle lid to closing the SG manhole)	Removal of the SG nozzle lid	Installation of the SG manhole				12		12		
8-3	A	Mid-loop operation with RHR cooling (from closing the SG manhole to RCS full)	Installation of the SG manhole	RCS full	Midloop, Late, Not Vented	The "midloop, late, not vented" is assumed to cover the state from the installation of SG monhole to the RCS full because there is no vent in this configuration. (The SG manhole is closed at the end of POS 8-2.)	24	24		11		
	B											
9		RHR operation (RCS is filled with coolant)	RCS full	Initiation of the RCS leakage test	Normal Pressurizer Level, Late	The "normal pressurizer level, late" is assumed to cover the state from the RCS full and the RCS lakage test to start-up.	96	98	8	129	10	
10		RCS leakage test (RHRS isolated from RCS)	Initiation of the RCS leakage test	End of the RCS leakage test					16		21	Not modeled in LPSD PRA
11		RHR operation (RCS is filled with coolant)	End of the RCS leakage test	Isolation of RHR (RCS temperature approaches 350F)					33		44	
12		Hot standby	Isolation of RHR	Critial state of the reactor					38		51	Not modeled in LPSD PRA
13		Low power operation	Critial state of the reactor	Power operation (for start-up)					3		4	Not modeled in LPSD PRA

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 668-5180 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:	**11/29/2010**

QUESTION NO. : 19.01-10

On page 19.1-963 of the DCD, Revision 2, Table 19.1-119, Key Insights and Assumptions, and in Section 5.4.7.2.3.6, of the DCD, it states, "Hydrogen peroxide addition is adopted instead of aeration because it decreases the duration of the mid-loop operation. As a result, the mid-loop operation is needed only to drain the SG primary side water while being able to maintain a high RCS water level for most of the oxidation operation". In US operating plants, often the duration of midloop is based on the time to install and remove SG nozzle dams to isolate the SGs to perform maintenance and testing. As the staff understands, MHI plans to use SG nozzle dams to isolate the SGs to perform maintenance and testing. The staff is requesting MHI to document in Section 5.4.7.2.3.6 and Table 19.1-119 of the DCD why hydrogen peroxide decreases the duration of midloop.

ANSWER:

The following design features of the US-APWR help to reduce the duration of mid-loop operations:

(a) Adoption of hydrogen peroxide
(b) Installation and removal of SG nozzle dams at the water level above the top of the main coolant piping (MCP)

Item (b) has been described in DCD Subsection 5.4.7.2.3.6 Item B "High RCS water level." MHI will document a description of Item (a) in Section 5.4.7.2.3.6 Item A "Chemical addition (hydrogen peroxide)." In addition, the above features will be incorporated in Table 19.1-119 as key assumptions during LPSD PRA. Detailed discussion of these items is provided below.

The elevation of the SG nozzles for the US-APWR is higher than the elevation for a typical

4-loop PWR plant. This design feature enables SG nozzle dams to be installed and removed when the MCP is filled with water. (Refer to DCD Subsection 5.4.7.2.3.6 Item B). Therefore, installation and removal of SG nozzle dams does not dominate the duration of mid-loop operation in the US-APWR design as it does for a typical 4-loop PWR.

Hydrogen peroxide addition is adopted instead of aeration because it decreases the duration of mid-loop operation; hydrogen peroxide addition operation does not require mid-loop duration. As a result of adopting hydrogen peroxide addition, which is done at a high RCS water level for most of the oxidation operation and a higher SG nozzle level, mid-loop operation is needed only to drain the SG primary side water, thus reducing overall duration of mid-loop operation.

Impact on DCD
The above discussion will be inserted in Section 5.4.7.2.3.6 and Table 19.1-119 as follows:

5.4.7.2.3.6 Mid-loop and Drain Down Operations

A. Chemical addition (hydrogen peroxide)
Hydrogen peroxide addition is adopted instead of aeration because it decreases the duration of mid-loop operation; hydrogen peroxide addition operation does not require mid-loop duration. As a result of adopting hydrogen peroxide addition which is done at a high RCS water level for most of the oxidation operation, and a higher SG nozzle level (Refer to Item B), ~~the~~ mid-loop operation is needed only to drain the SG primary side water, thus reducing overall duration of mid-loop operation ~~while being able to maintain a high RCS water level for most of the oxidation operation~~.

Table 19.1-119 Key Insights and Assumptions (Sheet 8 of 23)

Key Insights and Assumptions	Dispositions
20. Instrumentation piping is installed up side of the RV. No penetrations through the RV are located below the top of the reactor core. This minimizes the potential for a loss of coolant accident by leakage from the reactor vessel, allowing the reactor core to be uncovered.	5.3.3.1
21. Hydrogen peroxide addition is adopted instead of aeration to reduce the duration of mid-loop operation.	5.4.7.2.3.6
22. The SG nozzle dam installation level for the US-APWR is higher than in most conventional operating plants.	5.4.7.2.3.6

Impact on R-COLA and S-COLA
There is no impact on R-COLA and S-COLA..

Impact on PRA
There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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DATE OF RAI ISSUE:	**11/29/2010**

QUESTION NO. : 19.01-11
In Table 19.1-119, Key Insights and Assumptions, of the DCD, Revision 2, in assumption 4 on page 19.1-950, assumptions 6 and 7 on page 19.1-960, and assumption 7 on page 19.1-963, please update the disposition of these assumptions to include the new Technical Specification for automatic low pressur e letdown line isolation, TS 3.4.8.

ANSWER:

MHI will update the dispositions of the assumptions regarding automatic isolation of the low pressure letdown line. In addition to TS 3.4.8, the response to RAI 19.01-8 (RAI #628-4866) describing the automatic isolation function of the low pressure line will be incorporated in TS 3.9.6. Reference to these new TSs will be added to Table 19.1-119.

Impact on DCD
TS 3.4.8 and TS 3.9.6 will be inserted in Sheet 3 (page 19.1-950) and Sheet 16 (page 19.1-963) of Table 19.1-119, as shown on the marked-up page.

Impact on R-COLA
There is no impact on R-COLA .

Impact on PRA
There is no impact on PRA.

Table 19.1-119 Key Insights and Assumptions (Sheet 3 of 23)

Key Insights and Assumptions	Dispositions
- The RHR system is used to provide core cooling when the RCS must be partially drained to allow maintenance or inspection of the reactor head, SGs, or reactor coolant pump seals.	5.4.7.2.3.6
- During mid-loop operation, if the water level of the RCS drops below the mid-loop level, low pressure letdown lines are isolated automatically. This interlock is useful to prevent loss of reactor coolant inventory.	5.4.7.2.3.6 <u>TS 3.4.8</u> <u>TS 3.9.6</u>
5. Refueling Water Storage Pit	
- The RWSP is located on the lowest floor inside the containment. The coolant and associated debris from a pipe or component rupture (LOCA) and the containment spray drain into the RWSP through transfer pipes.	6.3.2.2.5
- Four independent sets of ECC/CS strainers located in the RWSP. The strainer design includes redundancy, a large surface area to account for potential debris blockage and maintain safety performance, corrosion resistance, and a strainer hole size to minimize downstream effects.	6.3.2.2.6

Table 19.1-119 Key Insights and Assumptions (Sheet 16 of 23)

Key Insights and Assumptions	Dispositions
7. For the US-APWR, low-pressure letdown line isolation valves are installed. One normally closed air-operated valve is installed in each of two low-pressure letdown lines that are connected to two of four RHR trains. During normal plant cooldown operation, these valves are opened to divert part of the normal RCS flow to the CVCS for purification and the RCS inventory control. These valves are automatically closed and the CVCS is isolated from the RHRS by the RCS loop low-level signal to prevent loss of RCS inventory at mid-loop operation during plant shutdown. There are no features that automate the response to loss of RHR.	19.2.5 COL 19.3(6) TS 3.4.8 TS 3.9.6