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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-12036

Subject: Revised Response to US-APWR DCD RAI No.668-5180 Revision 2 (SRP 19.01)

References: 1) Letter MHI Ref: UAP-HF-10344 from Y. Ogata to U.S. NRC "MHI's Responses to US-APWR DCD RAI No. 668-5180 Revision 2 (SRP 19.0)" dated December 27, 2010

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

Enclosed is the revised response to RAI contained within Reference 1.

Please contact Mr. Joseph Tapia, General Manager of Licensing Department, 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,
Director - APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure:

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

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NRO

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-12036
Docket Number 52-021

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

February, 2012

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

02/07/2012

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:

MHI will withdraw discussions regarding use of hydrogen peroxide at mid-loop from Chapter 5 and Chapter 19 (including table 19.1-119 *Key Insights and Assumptions*).

To reduce the duration of mid-loop, The US-APWR is designed so that SG nozzle dams may be installed to isolate the Steam Generator (SG) for inspection and testing without having to reduce RCS inventory.

This design feature is discussed in DCD Rev. 3 Subsection 5.4.7.2.3.6 Item B "High RCS water level." This feature is incorporated into Table 19.1-119 as a LPSD key assumption.

The elevation of the SG nozzles in the US-APWR design is higher than the elevation of the top of the main coolant piping, atypical for conventional 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 Rev. 3 Subsection 5.4.7.2.3.6 Item B). Therefore, installation and removal of SG nozzle dams does not contribute to the duration of mid-loop operations in the US-APWR design as this activity would for 4-loop PWRs without this design feature.

Impact on DCD

DCD in Sections 5.4.7.2.3.6A and 19.1 will be revised in accordance with this response. (See Attachment 1)

Impact on R-COLA

R-COLA Part 2 FSAR Table 19.1-119R will be revised, consistent with DCD Table 19.1-119.

Impact on S-COLA

S-COLA Part 2 FSAR Table 19.1-119R will be revised, consistent with DCD Table 19.1-119.

Impact on PRA

There is no impact on the PRA.

Impact on Topical/Technical Report

There is no impact on Topical and Technical Report.

5.4.7.2.3.6 Mid-loop and Drain Down Operations

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.

Mid-loop operation is a residual heat removal (RHR) operation where the RCS water level is brought to the middle portion of the main coolant piping (MCP) during outage for oxidation operation and installation/removal of steam generator (SG) nozzle cover. When the RCS water level decreases abnormally, air inadvertently gets into the residual heat removal system with the possibility of affecting the RHRS.

The features of mid-loop operation in US-APWR are shown as follows;

A. ~~Chemical addition (hydrogen peroxide)~~ DCD19.01-10 S01

~~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.~~ DCD_19.01-10

B. High RCS water Level

~~Keeping~~Maintaining a high RCS water level for the duration of SG primary side water drainage and vacuum venting operation decreases the possibility of air intake to the RHRS. Since the SG installation level for the US-APWR is higher than ~~in most plants~~the top of the MCP, a high RCS water level during ~~the oxidation operation does not affect~~ installation of the SG nozzle cover, ~~nor~~ does not introduce risk or interfere with the SG maintenance. DCD_19.01-10 S01 DCD_19.01-10 S01

C. Water level instrument

Redundant narrow range water level instrument and a mid-range water level instrument, which are shown in Figure 5.1-2 (Sheet 3 of 3), are provided to measure mid-loop water level. Installation of a redundant water narrow level instrument enhances reliability of the mid-loop operation.

A temporary mid-loop water level sensor that measures the RCS water level with reference to pressure at the reactor vessel head vent line and cross over leg is installed in addition to these permanent water level sensors to cope with surge line flooding events.

D. Interlock for abnormal water level decrease

When the water level of RCS drops below the RCS Low water level (0.47 feet higher than loop center)~~mid loop level~~, low pressure letdown lines are isolated automatically. This interlock is useful to prevent loss of reactor coolant inventory DCD_19-495

E. Water supply from spent fuel pit

Several of these POSs were excluded from modeling based on the reasons given in Table 19.1-81. Table 19.1-82 provides the assumed duration of the various POSs, and this duration takes into account the US operational PWR plant data extracted from EPRI TR 1003465 (Reference 19.1-53). Table 19.1-83 is a planned maintenance schedule created supposing the actual outage. Table 19.1-141 summarizes conditions considered in this LPSD PRA, and includes the configuration of the RCS, effectiveness of SG reflux cooling and gravity injection, time to RCS boiling and core uncovery, decay heat, key activities, etc., for each POS during mid-loop operation. Figure 19.1-23 shows the timeframe assumed in the LPSD PRA including RCS water level and key activities during mid-loop operation.

One of the characteristic designs of the US-APWR is installation and removal of the in-core instrumentation system (ICIS) from the top of the RV head. Operators can start to remove (before refueling) and install (after refueling) the ICIS after the end of RCS draining as shown in Figure 19.1-23. This action cannot be done during RCS draining, which results in an extended duration of mid-loop operation. During actual plant operation, the action to install or remove the ICIS is performed when the RCS water level is above the top of main coolant piping (MCP). In addition, high SG installation level of the US-APWR design enables to keep water level higher than the top of MCP during installation or ~~removal SG nozzle dams, SG maintenance and hydrogen peroxide operation~~removal of SG nozzle dams and SG maintenance. The LPSD PRA conservatively assumes that the actions are done with water level at the center of MCP. This assumption is used in the estimation of allowable time to core uncovery after a loss of RHR. DCD_19.01-10 S01

The following is the POS definition considered in the LPSD PRA. In addition, the key activities during the mid-loop operation to be expected as main contributors to CDF for LPSD are also described in the following:

- POS 1: Low power operation – Out of scope of US-APWR LPSD PRA

  POS 1 is a low power operation state. Normal plant shutdown is gradually decreasing a reactor power. The control mode of control rods is switched from automatic operation mode to manual operation mode. The turbine bypass control is also switched from T_{avg} control mode to steam pressure control mode, and the main feed water control is switched to the bypass control mode. When the turbine output decreases to 5% lower, the turbine is tripped and the control rods are inserted in the reactor fully. The end of POS 1 is defined as the time at which a control rod insertion into the core to shift to a hot standby state.

- POS 2: SG cooling without the RHR cooling – Out of scope of US-APWR LPSD PRA

  POS 2 is a hot standby state transitioning to hot shutdown with core cooling by use of the SGs. Using the turbine bypass valves (and/or the main steam release valve), the RCS is cooled down and de-pressurized from hot standby to hot shutdown. If the RCS is below a pressure of 400psig and a temperature of 350°F, The RHRS can be used as the RCS cooling system. Therefore, the end of POS 2 is defined as the time of RCS temperature reaching 350°F.

- POS 3: RHR cooling (RCS is filled with coolant)

  POS 3 is a hot shutdown and a cold shutdown state with cooling provided by the RHRS. When the RCS is below a pressure of 400 psig and a temperature of 350°F, the RHRS starts and cools the RCS. The end of POS 3 is defined as the timing of initiation of a draindown of the RCS because the change of RCS inventories level is the important factor for LPSD PRA.

- 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 RCS drain to the water level below the top of MCP by CVCS, and then SG drain ~~and hydrogen peroxide are done~~is performed. CS/RHR pump failure is considered due to the pump cavitations caused by decreasing the RCS inventory. After that, the RCS inventory is increased up to the water level above the top of MCP and maintained by CVCS. High SG installation level of DCD_19.01-10 S01
  US-APWR enables removal of SG manways and installation of SG nozzle dams at the higher water level. In addition, operators perform detensioning of the RV head stud bolts and removal of pressurizer safety valves and of ICIS from the top of RV head. At the late stage of this POS, RV head is removed when RCS inventory is one-foot below the flange level.At the end of POS4, 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 19.1-141 and Figure 19.1-13 to Figure 19.1-15.

  - POS 4-1: This POS begins at the initiation of the drain down process from the RCS full level to the water level below the MCP top. The end of POS 4-1 is the time at which the SG manways are removed. Decrease of the RCS inventory and maintaining water level are controlled by the CVCS. In POS 4-1, the reflux cooling by the SGs is available as a heat sink under the vented condition, but the gravity injection is unavailable because the RCS is not at atmospheric pressure.

    Key Activities of POS 4-1:

    - Pressurizer spray vent valve is opened for RCS draining, and then the RCS is drained below the top of MCP by the CVCS for SG draining.

    - The inventory of RCS is kept higher than the MCP top level by the CVCS after SG draining. Then, operations that loosen the RV head stud bolts for removal of the RV head and remove the ICIS from the top of RV head are started.

    - SG manways on hot leg side and then on cold leg side are removed (End of POS 4-1).

when the RCS water level is above the top of main coolant piping (MCP). In addition, high SG installation level of the US-APWR design enables to keep water level higher than the top of MCP during installation or ~~removal SG nozzle dams, SG maintenance and hydrogen peroxide operation~~removal of SG nozzle dams and SG maintenance. The LPSD PRA conservatively assumes that the actions are done with water level at the center of MCP. This assumption is used in the estimation of allowable time to core uncovery after a loss of RHR. DCD_19.01-10 S01

The release categories for the low power and shutdown conditions are defined on the basis of plant operational states (POSs). Frequency and source terms for each release category are quantified and the significant large release sequences are evaluated. The results of source term analysis are used for the inputs of offsite dose evaluation.

Release category for the low power and shutdown (LPSD) conditions is classified into two groups as below.

- Filled RCS state
- Mid-loop Operation State

Among the POSs for LPSD conditions considered in the US-APWR PRA, only POS3, POS4, POS8, POS9, and POS11 are considered for the release categories and source term evaluation to represent whether containment is open or not. In POS3, POS9, and POS11, which are categorized as the filled RCS state, the equipment hatch is expected closed because RCS temperature is still high or inspection cannot be carried out during the period. On the other hand, the equipment hatch is anticipated opened in POS4 and POS8 which are categorized as the mid-loop operation state.

In the quantification of the release categories, it is assumed that the radiological fission products are always released to the environment when core damage accident occurs, i.e. the conditional containment failure probability (CCFP) is equal to one. Regarding the source term evaluation, procedures to isolate the containment after onset of the accident are taken into account and therefore the retention of radiological fission products is considered.

19.1.6.2 Results from the Low-Power and Shutdown Operations PRA

Table 19.1-86 shows a summary of system unavailability of frontline systems. Table 19.1-87 shows a summary of system unavailability of support systems. LPSD initiating event frequencies are shown in Table 19.1-88.

As described in Subsection 19.1.6.1, the detailed analysis is performed for POS 4-3 and POS 8-1. The results are shown in Table 19.1-89 and Figure 19.1-25. As the result of detailed accident sequence quantification, CDFs for POS 4-3 and POS 8-1 are the following;

- CDF for POS 4-3: 3.0E-08/RY
- CDF for POS 8-1: 8.0E-08/RY

Table 19.1-119 Key Insights and Assumptions (Sheet 31 of 48)

Key Insights and Assumptions	Dispositions
LPSD assumptions	
1. Freeze plug may not be used for US-APWR because the isolation valves are installed considering maintenance and CCWS has been separated individual trains. Therefore, the freeze plug failure is excluded from the potential initiator.	COL 13.5(7)
2. ~~Hydrogen peroxide addition is adopted instead of aeration because it decreases the duration of the 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 higher SG nozzle level, the mid loop operation is needed only to drain the SG primary side water while, thus reducing overall duration mid loop operation.~~	~~5.4.7.2.3.6~~
3. Redundant narrow range water level instrument and a mid-range water level instrument are provided to measure mid-loop water level. Installation of a redundant water narrow level instrument enhances reliability of the mid-loop operation. A temporary mid-loop water level sensor that measures the RCS water level with reference to pressure at the reactor vessel head vent line and cross over leg is installed in addition to these permanent water level sensors to cope with surge line flooding events.	5.4.7.2.3.6 Figure 5.1-2
4. When the RCS is mid-loop operation with the closed state, the reflux cooling with the SGs is effective.	19.1.6 19.2.5 COL 19.3(6) COL 13.5(6)
5. Various equipments will be possible temporary in the containment during LPSD operation for maintenance. However, there are few possibilities that these materials fall into the sump because the debris interceptor is installed on the sump of US-APWR. Therefore, potential plugging of the suction strainers due to debris is excluded from the PRA modeling.	6.2.2

DCD_19.01-10 S01