MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

November 22, 2012

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-12314

Subject: MHI's Response to US-APWR DCD RAI No. 965-6710 (SRP 15.4.6)

Reference: 1) "Request for Additional Information No. 965-6710, SRP Section: 15.04.06 – Inadvertent Decrease in Boron Concentration in the Reactor Coolant (PWR) - Application Section: 15.4.3", dated October 9, 2012.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") the document entitled "MHI's Response to US-APWR DCD RAI No. 965-6710 (SRP 15.4.6)".

Enclosed is the response to the one RAI question contained within Reference 1.

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 with the information identified as proprietary redacted and replaced by the designation "[ ]".

This letter includes a copy of the proprietary version of the RAI response (Enclosure 2), a copy of the non-proprietary version of the RAI response (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all material designated as "Proprietary" in Enclosure 2 be withheld from disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

Please contact Mr. Joseph Tapia, General Manager of Licensing Department, Mitsubishi Nuclear Energy Systems, Inc., if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

Sincerely,

H. Nishio for.

Yoshiki Ogata
Director - APWR Promoting Department
Mitsubishi Heavy Industries, Ltd.

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NRO

Enclosures:

1. Affidavit of Hiroki Nishio
2. MHI's Response to US-APWR DCD RAI No. 965-6710 (SRP 15.4.6) (proprietary)
3. MHI's Response to US-APWR DCD RAI No. 965-6710 (SRP 15.4.6) (non-proprietary)

CC: J. A. Ciocco
J. Tapia

Contact Information

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ENCLOSURE 1

Docket No. 52-021
MHI Ref: UAP-HF-12314

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Hiroki Nishio, being duly sworn according to law, depose and state as follows:

1. I am Group Manager, Licensing Promoting Group in 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 "MHI's Response to US-APWR DCD RAI No. 965-6710 (SRP 15.4.6)", dated November 22, 2012, and have determined that the document contains 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 document indicates that information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The basis for holding the referenced information confidential is that it describes the unique design of the safety analysis, developed by MHI (the "MHI Information").

4. The MHI Information is not used in the exact form by any of MHI's competitors. This information was developed at significant cost to MHI, since it required the performance of research and development and detailed design for its software and hardware extending over several years. Therefore public disclosure of the materials would adversely affect MHI's competitive position.

5. The referenced information has in the past been, and will continue to be, held in confidence by MHI and is always subject to suitable measures to protect it from unauthorized use or disclosure.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information.

7. 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.

8. 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 and testing of new 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 22nd day of November, 2012.

H. Nishio

Nishio Hiroki
Group Manager – Licensing Promoting Group in APWR Promoting Department
Mitsubishi Heavy Industries, Ltd.

ENCLOSURE 3

UAP-HF-12314
Docket No. 52-021

MHI's Response to US-APWR DCD RAI No. 965-6710 (SRP 15.4.6)

November 2012

(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/22/2012

US-APWR Design Certification
Mitsubishi Heavy Industries
Docket No. 52-021

RAI NO.: **NO. 965-6710**

SRP SECTION: **15.04.06 – INADVERTENT DECREASE IN BORON CONCENTRATION IN THE REACTOR COOLANT (PWR)**

APPLICATION SECTION: 15.4.6

DATE OF RAI ISSUE: **10/09/2012**

QUESTION NO.: 15.04.06-11

In response to RAI 682-5367 (UAP-HF-11104) the applicant still requests that planned RCS dilutions in Modes 4 and 5, with no RCPs running, be allowed by TS. The staff is concerned that dilutions without an RCP running could create an unanalyzed condition where diluted water could potentially enter the core leading to a localized criticality. Has the potential of localized core dilutions been evaluated to support planned dilutions without RCPs running? Provide a detailed justification for why a localized criticality would not occur.

ANSWER:

As described in the response to RAI 682-5367 (UAP-HF-11104), the Technical Specifications (TS) have been revised to isolate all sources of unborated water to prevent the possibility of boron dilution during Modes 4 and 5 with no RCPs running. The TS do allow for a planned and procedurally controlled dilution operation. Additional information about these operations is provided in this RAI response.

In Modes 4 and 5, there is no dilution to reduce the boron concentration in RCS. However, there is a possibility of planned dilution such as chemical addition. During planned dilution, the normal dilution path is isolated and is not used in the planned dilution. Instead, chemical addition will be performed to control the primary water chemistry. This operation is referred to as a planned dilution because a small amount of water will be introduced to the RCS. Chemical addition will be performed by using the chemical mixing tank as described in DCD Subsection 9.3.4.2.4. A planned dilution in Modes 4 and 5, with no RCPs running is performed using a flow path from the chemical mixing tank to the CVCS charging pump suction side that is different than the normal dilution flow path. The description of this design feature will be added in DCD Subsection 9.3.4.2.4.

The chemical solution is added into the chemical mixing tank and is then transferred to the suction side of the charging pump to be pumped by the charging pump. The chemical solution flow rate is( ) The flow rate is limited by an orifice in the line. The description of this design feature will be added in the DCD Subsection 9.3.4.2.6.11. Therefore, the chemical solution is well mixed inside the charging pump with the normal charging flow, which has the same boron concentration as the RCS, and then flows into RCS. Therefore, a pure water slug cannot enter the core. During the planned dilution, the charging flow rate is 180 gpm. The boron concentration at the outlet side of the charging pump is decreased by only [ ] If the boron concentration at the inlet of the charging pump is assumed to be 4200 ppm [Note1], the boron concentration at the outlet of the charging pump is [ ]

The following two cases are considered in terms of determining the impact of this planned dilution.

1) Although the dilution flow is well mixed before entering the core by RHR flow, the reactivity impact of the dilution can be calculated by conservatively assuming no mixing. The result is that a reactivity of [ ] is added to a localized part of the core when the coolant flow with chemical solution enters the core, assuming no mixing by RHR flow. The TS require that greater than -1.0%Δk/k subcriticality be maintained in Modes 4 and 5. Therefore, subcriticality is maintained with margin even if very conservative assumptions are considered.

2) The TS requires all dilution paths be isolated within 15 minutes following the planned dilution. During this 15 minute period, the possible decrease in global RCS boron concentration is calculated using the equations described in MHI's revised response to US-APWR DCD RAI NO.311-2347, Question No.15.4.6-5 (UAP-HF-11006). The values used in the equations are:

   - RCS volume: [ ]
   - Initial RCS boron concentration: 4200 ppm
   - Chemical solution flow rate: [ ]
   - Dilution time: 15 minutes
   - Coolant densities of RCS and dilution flow are the same because the difference is negligible.

   ΔC= [ ]

   The reactivity insertion due to the dilution is [ ] Therefore subcriticality is maintained even if the dilution is assumed to continue for 15 minutes after the planned dilution is completed.

   This ΔC is for the whole RCS and would therefore be the concentration at the inlet of the charging pump. When the boron concentration at the inlet of the charging pump is [ ] after 15 minutes, the boron concentration at the outlet of the charging pump is [ ] This results in a conservative maximum possible local ΔC of [ ] The resulting local reactivity effect would be [ ]
   Since the global shutdown margin is greater than -1.0%Δk/k, subcriticality will be maintained with margin after the planned dilution is completed.

As described above, boron dilutions without an RCP running cannot create an unanalyzed condition where diluted water could potentially enter the core leading to a localized criticality.

Note 1: The maximum RWSP boron concentration, 4200 ppm, allowed by TS LCO 3.5.4 is assumed. The RCS boron concentration is usually much less than 4200 ppm in Modes 4 and 5. However, 4200 ppm is conservatively assumed in the calculation for Modes 4 and 5 because a higher boron concentration produces a higher difference in boron concentration, ΔC.

Note 2: Bounding boron worth is assumed.

Note 3: Mid-loop operation is considered.

Impact on DCD

DCD Subsection 9.3.4.2.4 and 9.3.4.2.6.11 will be revised to add the additional information as discussed in RAI response and as shown in the markup in Attachment 1.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

This completes MHI's response to the NRC's question.

Attachment - 1

During long term dilution, a primary makeup water supply line is routed to the VCT inlet. This flow mixes with the hydrogen blanket in the tank to ensure hydrogen entrainment in the water. If alternate dilution is necessary, the line routed to the suction side of the charging pump is utilized, in addition to the line to the volume control tank.

Boric acid can also be removed from the reactor coolant by utilizing the deborating demineralizer to compensate the fuel burn-up near the end of the core life.

9.3.4.2.3.2 pH Control

The chemical agent used for pH control is lithium hydride (LiOH). This chemical is chosen for its compatibility with the material and water chemistry of borated water, stainless steel and zirconium systems. In addition, lithium-7 is produced in the core region because of irradiation of the dissolved boron in the coolant.

A chemical mixing tank is provided to introduce the chemical solution to the suction of the charging pumps, as required to maintain the proper concentration of Li-7 in the RCS.

The chemical solution is added into the chemical mixing tank and is then flushed to the suction side of the charging pumps with the primary makeup water. To maintain the reactor coolant pH as shown in Chapter 5, Figure 5.2.3-1, the Li-7 concentration in the reactor coolant is controlled by feed of the LiOH from the chemical mixing tank and bleed of the reactor coolant to the cation bed demineralizer.

9.3.4.2.4 Oxygen Control

The CVCS provides control of the RCS oxygen concentration during plant startup from cold condition by employing hydrazine as an oxygen scavenging agent. The hydrazine solution is injected into the RCS in the same manner as described above for LiOH. Hydrazine is only used during the startup from cold shutdown condition. Chemical addition will be performed using a flow path from the chemical mixing tank to the CVCS charging pump suction side that is different than the normal dilution flow path. DCD_15.04.06-11

Control and scavenging of oxygen generated by water radiolysis in the core region during normal power operation is performed by supplying hydrogen to the reactor coolant. The VCT maintains sufficient hydrogen pressure; therefore, the equilibrium hydrogen concentration in the reactor coolant is maintained. Hydrogen is supplied from the hydrogen manifold, and the required pressure of the gas space in the VCT is maintained by a hydrogen supply pressure control valve. This control valve can be adjusted to provide appropriate equilibrium hydrogen concentration.

9.3.4.2.5 Boron Recycle Subsystem

The CVCS includes the boron recycle subsystem. The holdup tank receives the reactor coolant discharged from the RCS and other reactor coolant recyclable drains, that are recyclable water to be processed as makeup water and concentrated boric acid water.

The holdup tank is operated under a slight positive pressure. The tank has a vent header which operates in conjunction with the GWMS. The maximum pressure of the vent header is determined by the pressure control system located at the inlet of the waste gas

9.3.4.2.6.11 Chemical Mixing Tank

The chemical mixing tank is utilized for adding chemical solutions to perform pH control and oxygen removal of the reactor coolant (pH control is discussed in Section 9.3.4.2.3.2). The tank is made of stainless steel. The flow rate to add the chemical additions is limited by an orifice upstream of the chemical mixing tank. DCD_15.04.06-11

9.3.4.2.6.12 RCP Purge Water Head Tank

The reactor coolant pump purge water head tank is provided to continuously supply the purge water to the reactor coolant pump No.2 and No.3 shaft seals for cooling by utilizing static head. Makeup for the purge water in the tank is provided intermittently and automatically with the primary makeup water.

The gas space of the tank is connected to the reactor coolant drain tank to prevent oxygen intrusion into the tank.

9.3.4.2.6.13 Resin Fill Tank

The resin fill tank is provided to fill each demineralizer with fresh resins. The tank is capable of being connected to each demineralizer resin fill line with flexible hoses connected to the conical-shaped bottom of the tank. The slurry of resin mixed with makeup water flows into the demineralizer through the flexible hose.

9.3.4.2.6.14 Mixed Bed Demineralizers

Two mixed bed demineralizers are provided in the purification loop to maintain reactor coolant purity. Each demineralizer is sized to accept the full purification flow during normal plant operation and to have a minimum design life of one core cycle.

A mixture of cation and anion resins is utilized in the demineralizers to remove fission and corrosion products. The anion resin is converted to borate form by addition of reactor coolant containing boric acid. During the operation, if ion exchange capability of the resin is diminished, the other demineralizer is utilized.

The demineralizer vessel is made of stainless steel and is equipped with connections for the exchange of resins and a screen for resin effluent prevention.

Mixed bed demineralizers are provided with a resin-retaining screen on the backwash line and connected to a backwash water discharge line to the holdup tank. The screen and discharge line are designed to maintain Occupational Radiation Exposure (ORE) ALARA during resin back washing. DCD_12.03-48

9.3.4.2.6.15 Cation Bed Demineralizer

One cation resin bed demineralizer located downstream of the mixed bed demineralizers removes Li-7 produced in the reactor coolant and maintain the desired pH of the reactor coolant. The demineralizer is sized to provide adequate purification flow to control the Li-7 and/or the cesium concentration in the reactor coolant in the event of a fuel defect.