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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-10097

Subject: MHI's Amended Response to US-APWR DCD RAI No. 384-2862 Revision 0

References: 1) "Request for Additional Information 384-2862 Revision 0, SRP Section: 09.03.04 - Chemical and Volume Control System (PWR) (Including Boron Recovery System), Application Section: 9" dates June 8, 2009.
2) "MHI's Responses to US-APWR DCD RAI No. 384-2862 Revision 0, UAP-HF-09383, dated July 17, 2009"

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "MHI's Amended Response to US-APWR DCD RAI No. 384-2862 Revision 0." This amended response is submitted to address an administrative requirement to track the B-10 isotopic concentration in the refueling water storage pit and accumulators.

Enclosed is the amended response to the question No. 09.03.04-10 of the RAI (Reference 1). MHI replaces the previous response (Reference 2) with this amended response.

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.

D081
NRO

Enclosure:

1. MHI's Amended Response to US-APWR DCD RAI No. 384-2862 Revision 0

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Docket No. 52-021
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Enclosure 1

UAP-HF-10097
Docket No. 52-021

MHI's Amended Response to US-APWR DCD RAI No. 384-2862
Revision 0

April 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

04/07/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 384-2862 REVISION 0**
SRP SECTION:	**09.03.04 – Chemical and Volume Control System (PWR) (Including Boron Recovery System)**
APPLICATION SECTION:	**9.3.4**
DATE OF RAI ISSUE:	**6/8/2009**

QUESTION NO. : 09.03.04-10

1. How is the use of the boron recycle system and the potential recycling of depleted boron (depleted in 10B atom percent) back into the accumulator and refueling water storage pit addressed?
2. What measures are taken to ensure that the product of boron concentration (in ppm) and 10B atom percentage yield the expected negative reactivity assumed by the Chapter 15 accidents?
3. Provide the methodology for the determination of the 10B concentration (atom %) in the recycled boric acid and provide the frequency of that determination.

ANSWER:

The original response to this RAI was submitted by MHI letter UAP-HF-09383, dated July 17, 2009. This RAI response was discussed during a conference call between MHI and the NRC on January 29, 2010. As committed to during the conference call, the response to this RAI is amended as follows:

1. The B-10 isotopic concentration of the reactor coolant in the RCS is depleted very slowly with reactor operation due to the neutron flux in the core. When the boron recycle system is used, the reactor coolant containing depleted B-10 is recycled and returned to the RCS. After being recycled numerous times, the isotopic concentration of B-10 in the boric acid solution gradually decreases. During refueling outages, the reactor coolant in the RCS is mixed with the refueling water stored in the refueling water storage pit (RWSP). With the repeated mixing of each cycle, the isotopic concentrations of B-10 of the refueling water in the RWSP and accumulators that are filled from the RWSP can gradually decrease over a long period of time. Since the boron recycle system does not collect all of the boric acid solution, new boric acid is frequently supplied to the plant, and this contributes to the recovery of the B-10 isotopic concentration. Thus, the B-10 depletion will be small and will have a negligible impact on the negative reactivity assumed in the safety analysis. However, the amount of new boric acid that is added is dependent on the plant operations and it is difficult to predict the exact B-10 isotopic concentration from actual operating data. Therefore, in order to implement a more appropriate level of control, new Surveillance Requirements (SR) will be added to the Technical Specifications (TS) in DCD Chapter 16 in order to monitor the B-10 isotopic concentration in the RWSP and accumulators. The frequency of these SRs will be every 24

months. This frequency is considered conservative because the water in the RWSP and accumulators is not directly exposed to a significant neutron flux and the RWSP water is only mixed with the reactor coolant during outages.

2. The boron concentration (in ppm) limits of the RWSP and accumulator water is specified by the Technical Specifications (LCOs 3.5.4 and 3.5.1, respectively). The safety analyses for Chapter 15 accidents use boron concentrations within the TS limits based on natural boron (19.9% B-10 by atom percent). As discussed above, new SRs will be added to DCD Chapter 16 in order to verify that the boron concentration, including the B-10 isotopic concentration, is consistent with the assumptions for the Chapter 15 accidents.

3. The B-10 concentration (atom %) can be determined by using mass spectrometry method. The frequency of this measurement will be every 24 months. This frequency is considered conservative because the water in the RWSP and accumulators is not directly exposed to a significant neutron flux and the RWSP water is only mixed with the reactor coolant during outages.

Impact on DCD

DCD Chapter 16 LCOs 3.5.1 and 3.5.4, and their corresponding bases, will be revised as indicated in the attached markup pages.

Impact on COLA

There are impacts on the COLA to incorporate the DCD change.

Impact on PRA

There is no impact on the PRA.

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

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.5.1.6	Verify isotopic concentration of B-10 in each accumulator is ≥ 19.9% (atom percent).	[24 months OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.5.4.1	-----------------------------NOTE---------------------------- Only required to be performed when containment air temperature is < 32°F or >120°F. --- Verify RWSP borated water temperature is ≥ 32°F and ≤ 120°F.	[24 hours OR In accordance with the Surveillance Frequency Control Program]
SR 3.5.4.2	Verify RWSP borated water volume is ≥ 583,340 gallons.	[7 days OR In accordance with the Surveillance Frequency Control Program]
SR 3.5.4.3	Verify RWSP boron concentration is ≥ 4000 ppm and ≤ 4200 ppm.	[7 days OR In accordance with the Surveillance Frequency Control Program]
SR 3.5.4.4	Verify isotopic concentration of B-10 in the RWSP is ≥ 19.9% (atom percent).	[24 months OR In accordance with the Surveillance Frequency Control Program]

BASES

BACKGROUND (continued)

The B-10 isotopic concentration of the reactor coolant in the RCS is depleted very slowly with reactor operation due to the neutron flux in the core. When the boron recycle subsystem is used, the reactor coolant containing depleted B-10 is recycled and returned to the RCS. After being recycled numerous times, the isotopic concentration of B-10 in the boric acid solution being returned to the RCS gradually decreases. During refueling outages, the reactor coolant in the RCS is mixed with the refueling water stored in the RWSP. With the repeated mixing of each cycle, the isotopic concentration of B-10 of the refueling water in the RWSP can gradually decrease over a long period of time. Since the RWSP water may be used to add water inventory to the accumulators, the isotopic B-10 concentration in the accumulators may also gradually decrease over a long period of time. The depleted B-10 of the boric acid solution in the accumulators can be recovered by increasing the overall boron concentration or the B-10 isotopic concentration itself. The requirement to verify the B-10 isotopic concentration is only required if the boron recycle subsystem is used.

APPLICABLE SAFETY ANALYSES

The accumulators are assumed OPERABLE in both the large and small break LOCA analyses at full power (Refs. 1 and 3). These are the Design Basis Accidents (DBAs) that establish the acceptance limits for the accumulators. Reference to the analyses for these DBAs is used to assess changes in the accumulators as they relate to the acceptance limits.

In performing the LOCA calculations, conservative assumptions are made concerning the availability of ECCS flow. In the early stages of a LOCA, with or without a loss of offsite power, the accumulators provide the sole source of makeup water to the RCS. The assumption of loss of offsite power is required by regulations and conservatively imposes a delay wherein the SI pumps cannot deliver flow until the Class 1E gas turbine generators start, come to rated speed, and go through their timed loading sequence. In cold leg break scenarios, the entire contents of one accumulator are assumed to be lost through the break.

The limiting large break LOCA is a double ended guillotine break at the discharge of the reactor coolant pump. During this event, the accumulators discharge to the RCS as soon as RCS pressure decreases to below accumulator pressure.

BASES

APPLICABLE SAFETY ANALYSES (continued)

As a conservative estimate, no credit is taken for SI pump flow until an effective delay has elapsed. This delay accounts for the Class 1E gas turbine generators starting and the pumps being loaded and delivering full flow. The delay time is conservatively set with an additional 2 seconds to account for SI signal generation. During this time, the accumulators are analyzed as providing the sole source of emergency core cooling. No operator action is assumed during the blowdown stage of a large break LOCA.

The worst case small break LOCA analyses also assume a time delay before pumped flow reaches the core. For the larger range of small breaks, the rate of blowdown is such that the increase in fuel clad temperature is terminated solely by the accumulators, with pumped flow then providing continued cooling. As break size decreases, the accumulators and safety injection pumps both play a part in terminating the rise in clad temperature. As break size continues to decrease, the role of the accumulators continues to decrease until they are not required and the safety injection pumps become solely responsible for terminating the temperature increase.

This LCO helps to ensure that the following acceptance criteria established for the ECCS by 10 CFR 50.46 (Ref. 2) will be met following a LOCA:
~~BASES~~

~~APPLICABLE SAFETY ANALYSES (continued)~~

a. Maximum fuel element cladding temperature is ≤ 2200°F,

b. Maximum cladding oxidation is ≤ 0.17 times the total cladding thickness before oxidation,

c. Maximum hydrogen generation from a zirconium water reaction is ≤ 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react, and

d. Core is maintained in a coolable geometry.

Since the accumulators discharge during the blowdown phase and core reflooding phase of a LOCA, they do not contribute to the long term cooling requirements of 10 CFR 50.46.

The safety analysis assumes values of 19,338 gallons and 19,734 gallons.

BASES

APPLICABLE SAFETY ANALYSES (continued)

For both the large and small break LOCA analyses, a nominal contained accumulator water volume is used. The contained water volume is 3434 gallons larger than the deliverable volume for the accumulators, since the flow damper is near the bottom of the accumulators and the dead volume in each accumulator is 3434 gallons. For small breaks, an increase in water volume is a peak clad temperature penalty. For large breaks, an increase in water volume can be either a peak clad temperature penalty or benefit, depending on downcomer filling and subsequent spill through the break during the core reflooding portion of the transient. The safety analysis treats the volume of water from the accumulator to the RCS isolation check valves as accumulator injection line.

The minimum boron concentration setpoint is used in the post LOCA boron concentration calculation. The calculation is performed to assure reactor subcriticality in a post LOCA environment. Of particular interest is the large break LOCA, since no credit is taken for control rod assembly insertion. A reduction in the accumulator minimum boron concentration would produce a subsequent reduction in the available containment sump concentration for post LOCA shutdown and an increase in the maximum sump pH. The safety analysis assumes that the boron has the isotopic concentration of B-10 found in natural boron (19.9 atom percent). The maximum boron concentration is used in determining the cold leg to hot leg recirculation injection switchover time and minimum sump pH. The upper limit of boron concentration is not related to reactivity and is not dependent on the B-10 isotopic concentration.

~~BASES~~

~~APPLICABLE SAFETY ANALYSES (continued)~~

The large and small break LOCA analyses are performed at the minimum nitrogen cover pressure, since sensitivity analyses have demonstrated that higher nitrogen cover pressure results in a computed peak clad temperature benefit. The maximum nitrogen cover pressure limit prevents accumulator relief valve actuation, and ultimately preserves accumulator integrity.

The effects on containment mass and energy releases from the accumulators are accounted for in the appropriate analyses (Refs. 1 and 3).

The accumulators satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

BASES

LCO	The LCO establishes the minimum conditions required to ensure that the accumulators are available to accomplish their core cooling safety function following a LOCA. Four accumulators are required to ensure that 100% of the contents of three of the accumulators will reach the core during a LOCA. This is consistent with the assumption that the contents of one accumulator spill through the break. If less than three accumulators are injected during the blowdown phase of a LOCA, the ECCS acceptance criteria of 10 CFR 50.46 (Ref. 2) could be violated. For an accumulator to be considered OPERABLE, the isolation valve must be fully open, power removed above 1920 psig, and the limits established in the SRs for contained volume, boron concentration, and nitrogen cover pressure must be met.
APPLICABILITY	In MODES 1 and 2, and in MODE 3 with RCS pressure > 1000 psig, the accumulator OPERABILITY requirements are based on full power operation. Although cooling requirements decrease as power decreases, the accumulators are still required to provide core cooling as long as elevated RCS pressures and temperatures exist. This LCO is only applicable at pressures > 1000 psig. At pressures ≤ 1000 psig, the rate of RCS blowdown is such that the SI pumps can provide adequate injection to ensure that peak clad temperature remains below the 10 CFR 50.46 (Ref. 2) limit of 2200°F. In MODE 3, with RCS pressure ≤ 1000 psig, and in MODES 4, 5, and 6, the accumulator motor operated isolation valves are closed to isolate the accumulators from the RCS. This allows RCS cooldown and depressurization without discharging the accumulators into the RCS or requiring depressurization of the accumulators.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.1.6

Periodic verification every 24 months that the isotopic concentration of B-10 in each accumulator is ≥ 19.9% (atom percent) ensures that the B-10 isotopic concentration assumed in the accident analysis is available. [Since B-10 in the accumulators is not directly exposed to a significant neutron flux and the reactor coolant and RWSP water used as inventory for the accumulators is only mixed with the reactor coolant during outages, 24 months is considered conservative. OR The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk and is controlled under the Surveillance Frequency Control Program.]

REFERENCES

1. Subsection 6.2.1.
2. 10 CFR 50.46.
3. Subsection 15.6.5.
4. Subsection 19.1.4.1.2.
5. NUREG-1366, February 1990.

BASES

BACKGROUND (continued)

The B-10 isotopic concentration of the reactor coolant in the RCS is depleted very slowly with reactor operation due to the neutron flux in the core. When the boron recycle subsystem is used, the reactor coolant containing depleted B-10 is recycled and returned to the RCS. After being recycled numerous times, the isotopic concentration of B-10 in the boric acid solution being returned to the RCS gradually decreases. During refueling outages, the reactor coolant in the RCS is mixed with the refueling water stored in the RWSP. With the repeated mixing of each cycle, the isotopic concentration of B-10 of the refueling water in the RWSP can gradually decrease over a long period of time. The depleted B-10 of the boric acid solution in the RWSP can be recovered by increasing the overall boron concentration or the B-10 isotopic concentration itself. The requirement to verify the B-10 isotopic concentration is only required if the boron recycle subsystem is used.

~~BASES~~

APPLICABLE SAFETY ANALYSES

During accident conditions, the RWSP provides a source of borated water to the SI and CS System pumps. As such, it provides containment cooling and depressurization, core cooling, and replacement inventory and is a source of negative reactivity for reactor shutdown (Refs. 1 and 2). The design basis transients and applicable safety analyses concerning each of these systems are discussed in the Applicable Safety Analyses section of B 3.5.2, "Safety Injection System (SIS) - Operating," B 3.5.3, " Safety Injection System (SIS) - Shutdown," and B 3.6.6, "Containment Spray Systems." These analyses are used to assess changes to the RWSP in order to evaluate their effects in relation to the acceptance limits in the analyses.

The RWSP must also meet volume, boron concentration, and temperature requirements for non-LOCA events. The volume is not an explicit assumption in non-LOCA events since the required volume is a small fraction of the available volume. The deliverable volume limit is set by the LOCA and containment analyses. For the RWSP, the deliverable volume is different from the total volume contained since, due to the design of the tank, more water can be contained than can be delivered. The minimum boron concentration of 4000 ppm is an explicit assumption in the main steam line break (MSLB) analysis to ensure the required shutdown capability. The safety analysis assumes that the boron has the isotopic concentration of B-10 found in natural boron (19.9 atom percent).

The maximum temperature is an assumption in the steam generator tube rupture analysis; the minimum is an assumption in the MSLB.

BASES

APPLICABLE SAFETY ANALYSES (continued)

For a large break LOCA analysis, the minimum water volume limit of 329,150 gallons and the lower boron concentration limit of 4000 ppm (at the natural B-10 isotopic concentration) are used to compute the post LOCA boron concentration necessary to assure subcriticality. To secure this minimum water volume in the accident, RWSP needs to store boric acid water ≥ 583,340 gallons during normal operation. This water volume also bounds the ECCS and CSS pump NPSH Requirements. The large break LOCA is the limiting case since the safety analysis assumes that all control rods are out of the core.

The upper limit on boron concentration of 4200 ppm is used to determine the maximum allowable time to switch to hot leg recirculation following a LOCA. The purpose of switching from direct vessel injection to hot leg injection is to avoid boron precipitation in the core following the accident. The upper limit of boron concentration is not related to reactivity and is not dependent on the B-10 isotopic concentration.

In the ECCS analysis, the containment spray temperature is assumed to be equal to the RWSP lower temperature limit of 32°F. If the lower temperature limit is violated, the containment spray further reduces containment pressure, which decreases the rate at which steam can be vented out the break and increases peak clad temperature. The upper temperature limit of 120°F is used in the small break LOCA analysis and containment OPERABILITY analysis. Exceeding this temperature will result in a higher peak clad temperature, because there is less heat

~~BASES~~

~~APPLICABLE SAFETY ANALYSES (continued)~~

transfer from the core to the injected water for the small break LOCA and higher containment pressures due to reduced containment spray cooling capacity. For the containment response following an MSLB, the lower limit on boron concentration and the upper limit on RWSP water temperature are used to maximize the total energy release to containment.

The RWSP satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

The RWSP ensures that an adequate supply of borated water is available to cool and depressurize the containment in the event of a Design Basis Accident (DBA), to cool and cover the core in the event of a LOCA, to maintain the reactor subcritical following a DBA, and to ensure adequate level to support SIS and CS/RHR pump operation.

To be considered OPERABLE, the RWSP must meet the water volume, boron concentration, and temperature limits established in the SRs.

BASES

APPLICABILITY

In MODES 1, 2, 3, and 4, RWSP OPERABILITY requirements are dictated by the SIS and Containment Spray System OPERABILITY requirements. Since both the SIS and the Containment Spray System must be OPERABLE in MODES 1, 2, 3, and 4, the RWSP must also be OPERABLE to support their operation. Core cooling requirements in MODE 5 are addressed by LCO 3.4.7, "RCS Loops - MODE 5, Loops Filled," and LCO 3.4.8, "RCS Loops - MODE 5, Loops Not Filled." MODE 6 core cooling requirements are addressed by LCO 3.9.5, "Residual Heat Removal (RHR) and Coolant Circulation - High Water Level," and LCO 3.9.6, "Residual Heat Removal (RHR) and Coolant Circulation - Low Water Level."

ACTIONS

A.1 [and A.2]

With RWSP boron concentration or borated water temperature not within limits, they must be returned to within limits within 8 hours. Under these conditions neither the SIS nor the Containment Spray System can perform its design function. Therefore, prompt action must be taken to restore the tank to OPERABLE condition. The 8 hour limit to restore the RWSP temperature or boron concentration to within limits was developed considering the time required to change either the boron concentration or temperature and the fact that the contents of the tank are still available for injection. [Required Action A.2 allows the option to apply the requirements of Specification 5.5.18 to determine a Risk Informed Completion Time. This Required Action is not applicable in MODE 4.]

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.4.2

The RWSP water volume should be verified to be above the required minimum level in order to ensure that a sufficient initial supply is available for injection and to support continued SI pump and CS/RHR pump operation on recirculation. [Since the RWSP volume is normally stable and is protected by an alarm, a 7 day Frequency is appropriate and has been shown to be acceptable through operating experience. OR The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk and is controlled under the Surveillance Frequency Control Program.]

SR 3.5.4.3

The boron concentration of the RWSP should be verified to be within the required limits. This SR ensures that the reactor will remain subcritical following a LOCA. Further, it assures that the resulting RWSP pH will be maintained in an acceptable range so that boron precipitation in the core will not occur and the effect of chloride and caustic stress corrosion on mechanical systems and components will be minimized. [Since the RWSP volume is normally stable, a 7 day sampling Frequency to verify boron concentration is appropriate and has been shown to be acceptable through operating experience. OR The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk and is controlled under the Surveillance Frequency Control Program.]

SR 3.5.4.4

Periodic verification that the isotopic concentration of B-10 in the RWSP is ≥ 19.9% (atom percent) ensures that the B-10 isotopic concentration assumed in the accident analysis is available. [Since B-10 in the RWSP is not directly exposed to a significant neutron flux and the RWSP water is only mixed with the reactor coolant during outages, 24 months is considered conservative. OR The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk and is controlled under the Surveillance Frequency Control Program.]

REFERENCES

1. Subsection 6.2.2.

2. Subsection 15.6.5.