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

June 18, 2009

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-09329

Subject: MHI's Response to US-APWR DCD RAI No. 350-2675 REVISION 1

Reference: 1) "Request for Additional Information No. 350-2675 Revision 1, SRP Section: 05.02.03 - Reactor Coolant Pressure Boundary Materials, Application Section: DCD Tier 2, Section 5.2.3" dated May 04, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 350-2675 Revision 1."

Enclosed is the response to the RAI 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. Response to Request for Additional Information No. 224-2067 Revision 1

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

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Docket No. 52-021
MHI Ref: UAP-HF-09329

Enclosure 1

UAP-HF-
Docket Number 52-021

Response to Request for Additional Information
No. 350-2675 Revision 1

June 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

06/18/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 350-2675 REVISION 1**
SRP SECTION:	**05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS**
APPLICATION SECTION:	**DCD TIER 2, SECTION 5.2.3**
DATE OF RAI ISSUE:	**5/04/2009**

QUESTION NO.: 05.02.03-17

Background

RAI 05.02.03-2 (Reference 1) requested that the applicant explain the method of pH determination at operating temperature from Li and B inventories, and the method for ensuring the pH remains within a range that ensures materials integrity. RAI 05.02.03-2 also requested the applicant to explain any algorithms to be used and how they would involve online measurements and additions of either quantity, the limiting value for pH which would provoke major corrective action, and any conditions (e.g. shutdown) in which pH would be permitted to deviate significantly from standard conditions.

In the applicant's response (Reference 2), an explanation was given regarding the temperature at which limits were to be taken for DCD Table 5.2.3-2 (25°C) and DCD Section 9.3.4.2.3.2 (285°C), however the explanation given does not explain the wide differences in these two sections. Table 5.2.3-2 includes values as low as 4.2, which appears to be intended to cover refueling, and also allows pH as high as 10.5. Since normal operation should not exceed pH =7.4, it is difficult to envision circumstances when pH would rise this high.

Additionally, in the RAI response, the applicant added temperature and pH labels to the upper- and lower-limit lines in Fig. 5.2.3-1. However, the explanation of pH control in the text is inconsistent with the figure. DCD Figure 5.2.3-1 resembles Figures 2-4 and A-2 of the EPRI PWR Primary Water Chemistry Guidelines, Rev. 6 (EPRI guidelines). The supporting discussion and the pH labels on Figure 5.2.3-1 leave the impression that the Upper Limit and Lower Limit curves (each consist of 3 connected segments) are curves of constant pH. This is not the case, as can be seen from EPRI Guidelines Figs. 2-2, 2- 5, and Table A-3, where curves of constant pH are monotone decreasing. The middle region of constant lithium inventory (seen in both EPRI Guidelines Fig. 2-4 and DCD Fig. 5.2.3-1) is actually one of changing pH (increasing as boron decreases). (There is also such a flat region in EPRI Fig. 2-3.) The EPRI Guidelines describe different strategies of varying lithium and boron additions during startup and operation, and some of these strategies involve deliberate changes in pH over the course of operation (this is certainly true of the "modified" approach represented by Fig. 2-4). The DCD describes a plan of maintaining constant pH within limits, and does not mention any change in the limits over an operating cycle. Thus, the DCD text is inconsistent with both DCD Figure 5.2.3-1 and Figure 2-4 of the EPRI Guidelines, which both depict a modified chemistry regime in which the pH changes during the course of the cycle. The staff desires that applicant provide more detail regarding their approach to pH control. Simply referencing the "EPRI Model" is inadequate, since the EPRI guidelines does not clearly define a model, and mentions several that are in use.

Requested Information

1. Clarify whether the pH limits given in Table 5.2.3-2 are intended to cover all operating modes (e.g., refueling, cold shutdown, startup, shutdown, and power operation), and when it would be necessary to allow a pH as high as 10.5? Is this a limit to prevent materials damage or representative of an actual plant operating condition?

2. Describe the strategy for pH control for the entire operating cycles, including startup and full-power operation. Discuss any plans to vary pH over the course of the fuel cycle. Is the intent for the US-APWR to follow a modified chemistry regime as defined in the EPRI Guidelines?

ANSWER:

ANSWER to Requested Information-1:

Recommended pH range of Reactor Coolant Water Chemistry is described in Table-5.2.3-2 in the DCD. These values are pH at 25°C water chemistry condition.

Basically, pH of Reactor Coolant Water Chemistry is determined by boric acid and lithium concentration. Value of pH 4.2 (at 25°C) corresponds to combination of boron concentration 4000ppm and Li concentration 0.2ppm. Furthermore, pH 10.5 (at 25°C) corresponds to combination of boron concentration almost 0ppm and Li concentration 3.5ppm.

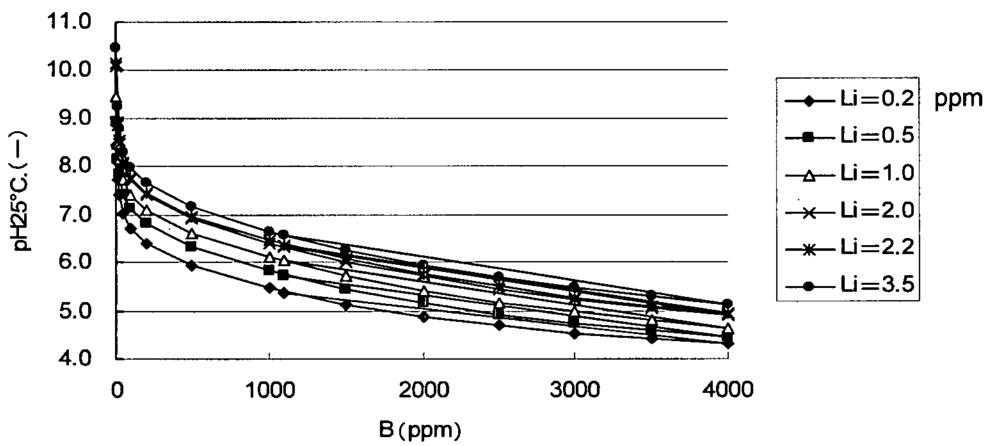

Fig.1 pH range at 25°C

Standard water chemistry contains a condition during hot functional test (HFT), that is "hydrogen + Li addition to pure water", to reduce amount of corrosion product from steam generator tube. during HFT, RCS water will be kept under condition that dissolved hydrogen concentration (DH) will be kept about 30 Ncc/kg, and lithium concentration will be kept about 0.5ppm. Under this condition, pH (at 25°C) will be about 10 at 25°C (see Fig.2). MHI apply this water chemistry for US-APWR.

Therefore, upper limit of pH 25°C is set as 10.5.

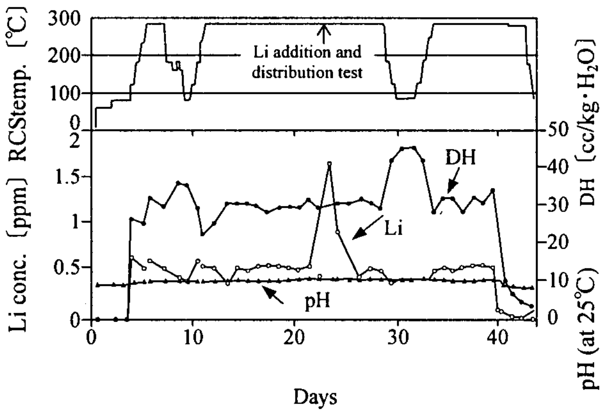

Fig.2 Water chemistry parameter during HFT

Moreover lower limit of pH 25°C is set regarding refueling water chemistry as NRC mentioned.

If pH is over or less than the pH range curve below, ingress of impurity may occur during construction, start-up, normal operation and shut-down. For example, pH (at25°C) will decrease from 4.2 to 4.1 by ingress of 1.5ppm HCl.

According to lithium control band during power operation in Figure-5.2.3-1 in the DCD, ranges of pH at 25°C (without impurity) are shown in Fig. 3. Value of pH is within 4.2 -10.5.

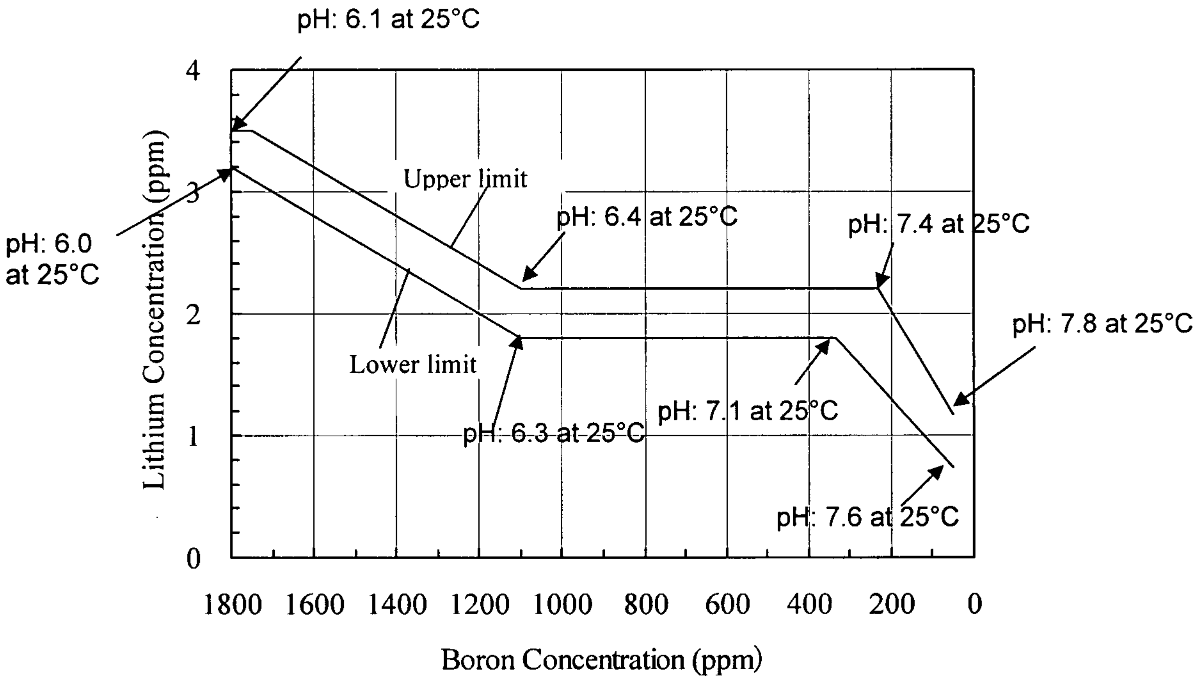

Fig.3 Change of pH at 25°C

Values of pH in several points are shown in Figure 4 below. In USA, high temperature pH is calculated under 300°C. Therefore, MHI calculates pH at 300°C. When boron concentration decreases from 1800 to 1100 ppm, pH is kept constant around 7.0. When boron concentration decreases from 1100 to almost 300 ppm, pH increases. When boron concentration decreases from almost 300 to 50ppm, pH is kept around 7.4 ± 0.1.

Optimum high pH value range at 300°C, shown in Fig. 4, is 6.9 to 7.5. In constant pH region where boron concentration less than 300ppm, pH value at 285°C is kept 7.3 ± 0.1. These values are consistent with DCD chapter 9.

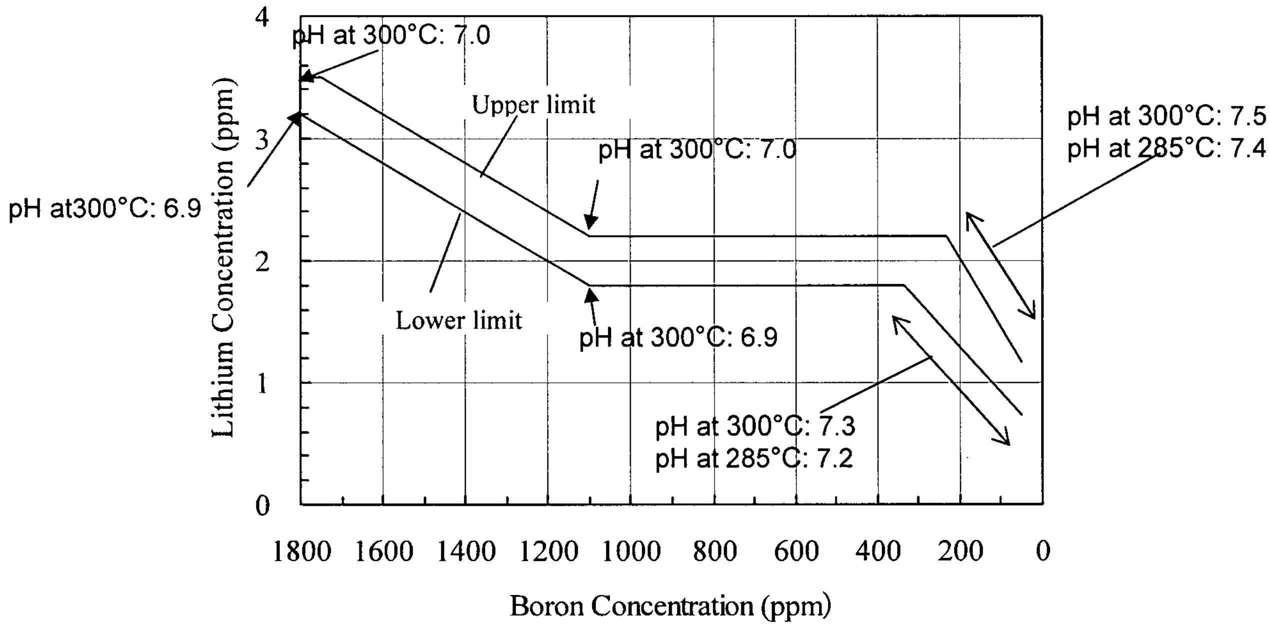

Fig.4 Change of pH at 300 and 285°C

As a result, pH values at 25°C are calculated as follows and MHI recommendation for the pH range (at 25°C) of RCS water is 4.2 to 10.5.

- HFT: pH 10.25 at 25°C (B: 0ppm, Li: 0.5ppm)
- Normal operation: 6.0 – 7.8 at 25°C (B: 50 – 1800ppm, Li: 1.17 - 3.5ppm)
- Shut-down and start up: 4.2 – 5 at 25°C (B: 2000- 4000ppm, Li: 0.2 - 0.5ppm)

ANSWER to Requested Information-2:

Li control band of US-APWR is shown in Figure-5.2.3-1 in the DCD. This control band during operation is consistent with modified chemistry regime in the EPRI Guidelines.

Almost twenty years ago, boron concentration at Beginning of Cycle (BOC) was lower than 1100ppm. In this case, upper lithium concentration was set at 2.2ppm. However, recent boron concentration would be higher than 1100 ppm, and necessity of increasing lithium occurred.

MHI decided that lower limit of lithium should be controlled to keep high pH temperature pH 6.8 at 285°C (6.9 at 300°C) to keep fuel material integrity. Also, upper limit of lithium concentration was set at 3.5 ppm. This concept is the same as EPRI Guidelines. Reason that MHI choose the concept of EPRI Guidelines was that there were many actual experiences of lithium control in USA and there was no trouble.

In the other operation modes (shut-down, refueling and start up), boron concentration is increased to refueling concentration (about 2000 – 3000ppm). During these periods, lithium concentration is reduced to make coolant pH low (about 0.5ppm, which means about pH 5 at 25°C). Purpose of pH control is to remove corrosion products. Under low pH condition, solubility of corrosion product is high.

Impact on DCD

MHI will revise Figure-5.2.3-1 in the DCD like Fig.4.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA