**MITSUBISHI HEAVY INDUSTRIES, LTD.**
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**TOKYO, JAPAN**

October 7, 2008

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-08226

**Subject: MHI's Response to US-APWR DCD RAI No. 71-986**

**References:** 1) "Request for Additional Information No. 71-986 Revision 0, SRP Section: 03.06.02 – Determination of Rupture Locations and Dynamic Effects Associated with Postulated Rupture of Piping," dated September 9, 2008

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") the document as listed in Enclosures.

Enclosed is the response to RAI 71-986, questions 1-9 and 16-19, 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. 71-986, Revision 0, Questions 1-9 and 16-19"

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-08226
Docket No. 52-021

Response to Request for Additional Information No. 71-986, Revision 0

Questions 1-9 and 16-19

October 2008

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** **NO. 71-986 REVISION 0**

**SRP SECTION:** **03.06.02 - DETERMINATION OF RUPTURE LOCATIONS AND DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING**

**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-1**

Branch Technical Position (BTP) 3-4, Part B, Items A(i) and B(i) provide guidance for separation provisions of plant arrangement for protection of essential systems and components against postulated failures of high and moderate energy piping systems, respectively. Both Items A(i) and B(i) of BTP 3-4 refer to the separation provisions of plant arrangements as specified in BTP 3-3, Item B.1.a. However, the staff did not find in US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2 the use of separation provisions of plant arrangement for protection against postulated pipe failures. The staff also noted that DCD Section 3.6.1.2.2.1 provides a multi-step process to develop the placement of safety-related SSCs for protection against pipe breaks using separation criteria for fluid systems in both inside and outside the containment, which does not address all provisions specified in Item B.1.a of BTP 3-3. Describe the separation criteria that satisfy the staff positions stated in BTP 3-4, Part B, Items A(i) and B(i) for protection against postulated failure of high- and moderate-energy fluid systems, respectively, for rupture locations in both inside and outside containment.

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**ANSWER:**

Since Subsection 3.6.1 of RG 1.206 requires describing the plant design for protection against piping failures, DCD Subsection 3.6.1.2.2.1 describes the separation as one of the protection methods. In order to prevent duplication, DCD Subsection 3.6.2 does not describe separation.

BTP 3-3 Part B, Item 1.a has the following requirements.

(1) In the break exclusion zone of main steam piping and feedwater piping, the environmental condition due to 1ft$^2$ pipe break is to be considered for design.

(2) High-energy fluid system piping is not to be located close to main control room.

DCD Subsection 3.6.2.1.1.1, "Application to Main Steam Pipe Room," addresses requirement (1) and DCD Subsection 3.6.1.2.3.2, "MCR Habitability," addresses requirement (2) of BTP 3-3 Part B, Item 1.a.

As for the criterion of BTP 3-4, Part B, Items A(i) and B(i), DCD Subsection 3.6.1.2.2.1 describes the design methodology of separation and notes that drawings will be included in the technical report "Pipe Break Hazard Analysis Report," which is to be issued as discussed in response of RAI 71-986, Question 03.06.02-18.

**Impact on DCD**

There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**QUESTION NO. : 03.06.02-2**

BTP 3-4, Part B, Item A(ii) states that breaks and cracks need not be postulated in those portions of piping from containment wall to and including the inboard or outboard isolation valves with additional design considerations. However, the staff noted that in US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.1.1.1 for high energy fluid system piping in PCCV penetration area, MHI states that breaks and cracks are not postulated in those portions of piping from the PCCV penetration to an anchor or five-way restraint and provides criteria that must be evaluated for Class 2 piping in this break exclusion area. The staff also noted that no criteria for Class 1 piping are included for this break exclusion area. Clarify the following issues related to the break exclusion criteria:

(a) DCD Section addresses only Class 2 piping in the break exclusion area near containment penetrations. Clarify whether there is any Class 1 piping subject to pipe break evaluation in this area. If yes, then provide design criteria that will be used for these Class 1 pipe segments.

(b) DCD Section defines the break exclusion area from the PCCV penetration to an anchor or five-way restraint, while BTP 3-4 defines this from containment wall to and including the inboard or outboard isolation valves. Explain, possibly with sketches, how the DCD definition of the break exclusion area includes both inboard and outboard isolation valves or confirm that the break exclusion area includes only the outboard valves within the main steam pipe room, as shown in DCD Figure 3.6-1. Also, if the break exclusion region defined in the DCD is beyond the outboard isolation valve, justify the differences between the DCD criteria and the staff position in BTP 3-4.

(c) DCD Section does not address several design stress limits and other conditions addressed in BTP 3-4, Part B, Items A(ii)(1)(d) involving ASME NC-3653

equations 9 and 10 and A(ii)(1)(e) involving primary loads and B31.1 piping design. Explain why these criteria are not applicable to APWR standard plant.

(d) DCD Section does not address the design condition in BTP 3-4, Part B, Item A(ii)(4) on minimum length criterion. Explain why this criterion is not applicable to APWR standard plant.

(e) BTP 3-4, Part B, Item A(ii)(5) states that welded attachments, for pipe supports or other purposes, to the break exclusion portion of piping should be avoided. Where welded attachments are necessary, the welds are 100% volumetrically examinable and detailed stress analyses are performed to demonstrate compliance with the limits of A(ii)(1). It appears to the staff that Item (5) in the DCD Section is consistent with these BTP requirements. However, DCD Figure 3.8.1-8 showing both mechanical and electrical penetrations in the containment design indicates welded connections between the thickened pipe and the end cap attached to the extended containment sleeve. Clarify if these welds satisfy the criteria described above.

(f) DCD Section referring to main steam pipe room states that no breaks are postulated in the main steam supply system (MSS) and feedwater system (FWS) piping from PCCV penetration outboard weld to the wall of the main steam room (see DCD Figure 3.6-1) provided three specific actions listed in the DCD are satisfied. Clarify if all three actions described in the DCD are also applicable to the portion from the inboard isolation valve to the containment penetration weld for the MSS and FWS.

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**ANSWER:**

(a) There is no Class 1 piping in PCCV penetration area (piping from PCCV penetration wall to and including the inboard or outboard isolation valves).

(b) In the MHI design practices applicable to Japanese PWR plants, as described in DCD Subsection 3.6.1.2.3.3, an anchor or five-way restraint is located as close as practical to the containment isolation valves inside and/or outside of the PCCV to assure operability of the isolation valve and preserve the integrity of the PCCV penetration area. MHI design practices therefore include a break exclusion zone between the isolation valve inside and/or outside of the PCCV and the anchor point or five-way restraint, which is different than the break exclusion zone defined in BTP 3-4. Refer to RAI 71-986 Question No. 03.06.02-2, Appendix A, for a summary of MHI break exclusion zone design practices applicable to Japanese PWR plants.

If it is not acceptable to apply the break exclusion zone between the isolation valve and anchor or five-way restraint, a piping design without an anchor or five-way restraint close to the isolation valve will be implemented to preclude the anchor or five-way restraint from being postulated as a pipe break point.

In recognition of the RAI comment, MHI design practices applicable to Japanese PWR plants will therefore not be applied to the US-APWR. The pipe break exclusion zone is limited to those portions of piping from the PCCV penetration wall up to and including the inboard or outboard isolation valves as described in BTP 3-4.

(c) The design stress limits specified by BTP 3-4 Part B Item A(ii)(1)(d) are equal to the threshold stress for postulated breaks in piping other than at the CV boundary. Therefore, DCD Revision 0, Subsection 3.6.2.1.1.1, which describes the requirements for the break exclusion zone at the CV boundary, specifies the stress is not to exceed the threshold stress by describing "(2) Stresses do not exceed those specified within Subsection 3.6.2.1."

To clarify the stress that is not to be exceeded, DCD Subsection 3.6.2.1.1.1 item (2) has been changed in Revision 1 to state "(2) Stresses do not exceed those specified within Subsection 3.6.2.1.1.2."

In the MHI design practices mentioned in item (b), the exception specified in BTP 3-4 Part B Item A(ii)(1)(e) is not necessary because maximum stresses satisfy the allowable stresses. However, MHI design practices applicable to Japan are not employed in the US-APWR, therefore the exception is necessary and the expression of "Primary loads include ..." in BTP 3-4 Part B Item A(ii)(1)(e) is added.

(d) The pipe length for the US-APWR is to be designed as the shortest practical for the subject portion. The expression of "minimum length practical" is considered as guidance, and therefore the minimum length criterion was not described further. To clarify compliance with BTP 3-4, the minimum length criterion for fluid system piping in containment penetration areas will be added in DCD Revision 2.

(e) Welds of PCCV penetrations for high-energy fluid system piping which is located between the inner side of flat heads and pipes do not satisfy the criterion of BTP 3-4, Part B, Item A(ii)(5). Therefore, these penetrations will be modified with welded attachments to the flued head structure to satisfy the criterion of BTP 3-4, Part B, Item A(ii)(5). BTP 3-4, Part B, Item A(ii)(5) is applicable only to high-energy fluid system piping penetrations and therefore is not applied to moderate-energy fluid system piping penetrations and electrical penetrations.

(f) The break exclusion zone requirements described in the DCD for the main steam room are not applicable inside the PCCV, because there are no isolation valves inside of PCCV.

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

(a) There is no impact on the DCD.

(b) Subsection 3.6.1.2.3.3 is deleted in its entirety.

Replace the first paragraph of Subsection 3.6.2.1.1.1 with:

- "Breaks and cracks need not be postulated in those portions of piping from containment wall to and including the inboard or outboard isolation valves. This portion of piping meets the following criteria."

Replace Item (3) of 2nd paragraph of Subsection 3.6.2.1.1.1 with:

- "The maximum stress in this piping as calculated by Equation 9, of paragraph NC-3653 of ASME Code, Section III (Reference 3.6-9) does not exceed the smaller of 2.25 $S_h$ or 1.8 $S_y$, when subjected to the combined loading of internal pressure, dead weight and postulated pipe rupture beyond this portion of piping, except that following a failure outside containment, the pipe between the outboard isolation valve and the first restraint may be permitted higher stresses provided a plastic hinge is not formed, operability of the valves with such stresses is ensured in accordance with the criteria specified in SRP Section 3.9.3, the piping between the outboard isolation valve and the restraint is constructed in accordance with the Power Piping Code ANSI B31.1 and the piping should either be of seamless construction with full radiography of all circumferential welds or all longitudinal and circumferential welds should be fully radiographed.

  Primary loads include those which are deflection-limited by whip restraints."

(c) The 2nd paragraph of Subsection 3.6.2.1.1.1 is to incorporate the following change:

- "(3) ... when subjected to primary loads, including those which are deflection-limited by whip restraints, and the combined loading of internal pressure, dead weight and postulated pipe rupture beyond this portion of piping."

(d) Add the following criteria at the end of the 2nd paragraph of DCD Revision 1, Subsection 3.6.2.1.1.1:

- "(8) The length of these portions of piping is to be reduced to the minimum length practical."

(e) The structural explanation in Subsection 3.8.1.1.4 for the penetrations of main steam piping, feedwater piping, and SG blow down piping will be modified from structure with welded attachments to the flued head structure.

The penetration structure for high-energy fluid system piping in Figure 3.8.1-8 will be modified to the flued head structure.

(f) There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

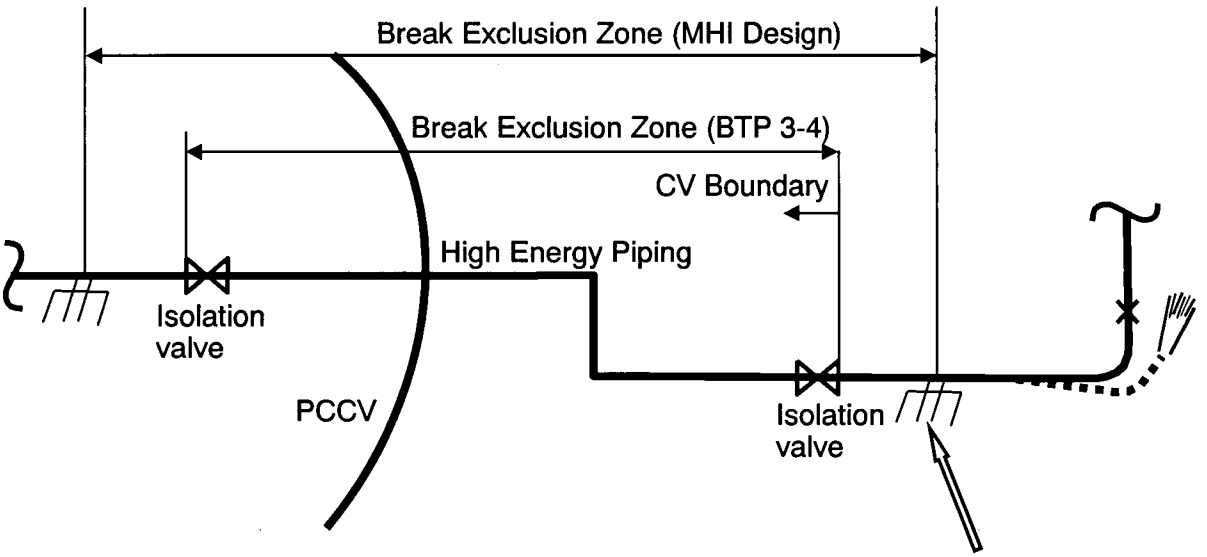
**RAI 71-986 Question No. 03.06.02-2**

**Appendix A**

**MHI Break Exclusion Zone Design Practices Applicable to Japanese PWR Plants**

The following are MHI design practices on high energy piping at PCCV penetrations:

(1) An anchor point or five-way restraint is installed outside the CV boundary near the CV inboard and/or outboard isolation valve. Hereinafter, the anchor point or the five-way restraint, as applicable, is referred to as the anchor.
(2) The anchor is designed to resist a pipe break at an arbitrary location outside the CV boundary.
(3) The break exclusion zone is applied within the CV boundary, and to piping between the CV outboard isolation valve and the anchor. No pipe break is postulated in this region.
(4) Through (1) to (3), the function of the CV isolation valve and the structural integrity of the pipe at the CV boundary are assured against the high energy pipe break outside CV boundary.




Anchor or five-way restraint is installed at nearby CV isolation valve in order to protect the CV boundary against high energy pipe break outside the CV.

Since it is a basic requirement to protect against a pipe break within the CV boundary, it is desirable to protect the integrity within the CV boundary against a pipe break at any arbitrary location outside the CV boundary. An anchor installed near the CV isolation valve is designed to protect against any postulated pipe break between CV isolation valve and the anchor. Therefore, the break exclusion zone is extended to include this area.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

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**SRP SECTION:** **03.06.02 - DETERMINATION OF RUPTURE LOCATIONS AND DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING**

**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-3**

BTP 3-4, Part B, Item A(iii)(4) addresses the design of the separating structure between a high-energy line and an essential component. It states that the separating structure should be designed to withstand the consequences of the pipe break in the high-energy line which produces the greatest effect at the structure. Also, BTP 3-4, Part B, Item A(iii)(5) states that safety-related equipment must be environmentally qualified in accordance with SRP Section 3.11. It further states that appropriate pipe breaks and leakage cracks should be included in the design bases for defining the qualifying environment for electrical and mechanical equipment both inside and outside the containment. However, the staff noted that US-APWR DCD does not address these two criteria. Explain why these two specific criteria are not applicable to APWR plant design.

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**ANSWER:**

Criterion of BTP 3-4, Part B, Item A(iii)(4) is to be added to DCD Subsection 3.6.2.1.1.2.

The fourth bullet of the third paragraph of DCD Subsection 3.6.1 addresses "Environmental evaluation of safety-related SSCs subject to the effects of postulated piping failure addressed in Section 3.11." This description coincides with the criterion of BTP 3-4, Part B, Item A(iii)(5).

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

- Add the following as the 2nd paragraph in Subsection 3.6.2.1.1.2: "For structures that separate a high-energy line from an essential component, the separating structure is designed to withstand the consequences of the pipe break in the high-energy line, which produces the greatest effect at the structure, irrespective of the fact that the following criteria might not need such a break location to be postulated."

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

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**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-4**

BTP 3-4, Part B, Item A(iv) states that in complex systems such as those containing arrangements of headers and parallel piping running between headers, the designer should identify and include all such piping within the designated run in order to postulate the number of breaks required by the criterion in BTP 3-4, Part B, Item A(iii). Clarify if this criterion is applicable to APWR for postulating pipe break locations.

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**ANSWER:**

The US-APWR does not intend to utilize any high-energy fluid piping in complex systems, such as those containing arrangements of headers and parallel piping running between headers, in areas which contain safety-related components necessary to be protected. Therefore, the criterion in BTP 3-4, Part B, Item A(iv), as it relates to complex systems, is not described.

MHI is of the opinion that piping runs in complex systems are inherently within the scope for consideration of the criterion if they exist. It does not appear necessary to specifically note in the DCD to include any complex systems when identifying which piping runs were considered to potentially contain postulated break locations pursuant to Item 2.A(iii) of BTP 3-4, Part B. Further, Subsection 3.6.2 includes a reference to BTP 3-4 and therefore the designer is required by reference to invoke the criterion of Part B, Item A(iv) if any future pipe configuration includes applicable headers and parallel piping running between headers. Based on this existing reference in the DCD and this RAI response, there is no intention to add a clarifying statement to the DCD unless it is determined necessary to state special requirements for complex systems.

**Impact on DCD**

There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-5**

BTP 3-4, Part B, Item B(iii)(1) states that leakage cracks should be postulated in piping located adjacent to SSCs important to safety. In Section 3.6.2.1.2.2 for moderate-energy fluid system piping outside the break exclusion area, MHI states that leakage cracks are postulated in the piping systems located adjacent to SSCs required for safe shutdown. Since this criterion should be applicable to all SSCs important to safety in addition to SSCs required for safe shutdown, the staff noted that the SSCs required for accident mitigation and other functions that are important to safety should also be included in postulating leakage cracks. Clarify the difference between SSCs important to safety and SSCs required for safe shutdown and justify why these criterion are not applicable to all SSCs important to safety.

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**ANSWER:**

The terminology "SSCs required for safe shutdown" is synonymous with "SSCs important to safety". For consistency, "SSCs required to safe shutdown" is to be changed to "SSCs important to safety".

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

- Change the 1st sentence of the 1st paragraph in Subsection 3.6.2.1.2.2 to: "Leakage cracks are postulated in the following piping systems located adjacent to SSCs important to safety."

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

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**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-6**

The criteria for moderate-energy fluid system pipe crack postulations in systems outside the break exclusion area in US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.1.2.2 do not include several items specified in BTP 3-4, Part B, Item B(iii). Clarify/justify the following:

(a) The staff noted that DCD did not address pipe break criteria for ASME Code, Section III, Class 1 piping as specified in BTP 3-4, Part B, Item B(iii)(1)(b). Clarify if APWR standard plant design includes Class 1 moderate-energy fluid system piping in areas other than the break exclusion area for pipe break evaluation.

(b) BTP 3-4, Part B, Item B (iii)(2) states that leakage cracks, unless the piping system is exempted by Item B (iii)(1), should be postulated at axial and circumferential locations that result in the most severe environmental consequences. MHI's criterion on this in DCD Section 3.6.2.1.2.2 (second bullet) refers to only axial locations. Justify why this criterion is not applicable to circumferential locations.

(c) BTP 3-4, Part B, Item B (iii)(3) states that leakage cracks should be postulated in fluid system piping designed to non-seismic standards as necessary to satisfy staff position in item B.3.d of BTP 3-3, which requires that the functional capability of essential systems and components should be maintained after a failure of piping not designed to seismic Category I standards, assuming a concurrent single active failure. Explain why this criterion is not applicable to piping in areas other than the break exclusion area for pipe break evaluation.

(d) BTP 3-4, Part B, Item B(iv) states that for moderate-energy fluid systems in proximity to high-energy fluid systems, where a postulated leakage crack in the moderate-energy fluid system piping results in more limiting environmental conditions than the break in proximate high-energy fluid system piping, the

provisions of B(iii) should be applied. Clarify whether this criterion is applicable to moderate-energy piping for pipe break evaluation for APWR design.

(e) BTP 3-4, Part B, Item B(v) states that for fluid systems qualifying as high-energy or moderate-energy fluid systems, through-wall leakage cracks instead of breaks may be postulated in the piping of those fluid systems that qualify as high-energy fluid systems for only a short operational period (i.e., about 2% of the time) but qualify as moderate-energy fluid systems for the major operational period. The staff noted that in DCD Section 3.6.1.1, Item B.2, MHI provides the technical basis for considering a high-energy line operating for a short period to be considered as a moderate-energy fluid system piping. Confirm if the criterion related to through-wall leakage cracks in this group of moderate-energy fluid system piping is applicable to APWR design.

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**ANSWER:**

(a) The criterion of BTP 3-4, Part B, Item B(iii)(1)(b) was inadvertently omitted. This criterion is to be added to DCD Subsection 3.6.2.1.2.2.

(b) The criterion for locations of circumferential leakage cracks is described in DCD Subsection 3.6.2.1.3.3 as follows: "Leakage cracks are postulated in those circumferential directions that result in the most severe environmental, spray wetting, and flooding consequences."

(c) DCD Subsection 3.6.2.1.2.2 specifies that the crack is postulated for non-seismic moderate-energy fluid piping systems. DCD Subsection 3.6.1.1.G also specifies that single active component failure is assumed as well as postulated piping failure. These specifications are also applicable to non-seismic category.

(d) DCD Subsection 3.6.2.1.2.2 describes that breaks of moderate-energy fluid system piping is not necessary to postulate if the breaks of moderate-energy fluid system piping is less severe than those of the adjacent high-energy fluid system piping. If the effects of breaks of moderate-energy fluid system piping is more severe than those of high-energy fluid system piping, then the criterion of BTP 3-4, Part B, Item B(iii) should be followed so that criterion of BTP 3-4, Part B, Item B(iv) is applicable.

(e) Yes, the criterion related to through-wall leakage cracks in moderate-energy fluid system piping based on the 2% rule is applicable to APWR design.

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

(a) Before the first bullet of the first paragraph of DCD Subsection 3.6.2.1.2.2, the following criterion of BTP 3-4, Part B, Item B (iii) (1) (b) is to be added:

"• For ASME Code, Section III, Class 1 piping, where the stress range calculated by Eq. (10) in NB-3653 is less than 1.2 S(m)"

(b) There is no impact on the DCD.

(c) There is no impact on the DCD.

(d) There is no impact on the DCD.

(e) There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

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**APPLICATION SECTION:** **3.6.2**

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**QUESTION NO. : 03.06.02-7**

BTP 3-4, Part B, Items C(i), C(ii), and C(iii) address circumferential pipe breaks, longitudinal pipe breaks, and leakage cracks, respectively. In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.1.3, MHI provides the criteria for defining break and crack types in both high- and moderate-energy fluid systems piping. Section 3.6.2.1.3.1 provides criteria for circumferential pipe breaks, Section 3.6.2.1.3.2 on longitudinal pipe breaks and Section 3.6.2.1.3.3 on leakage cracks. The staff did not find some of the requirements addressed in the corresponding BTP sections. Clarify the following:

(a) BTP 3-4, Part B, Item C(i)(2) states that where break locations are selected without the benefit of stress calculations, breaks should be postulated at the piping welds to each fitting, valve or welded attachment. In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.1.3.1, MHI stated that break locations are postulated at each fitting, valve or welded attachment. Clarify if the break is postulated at or within the fitting or at the piping weld to the fitting.

(b) BTP 3-4, Part B, Item C(i)(3) states that circumferential breaks should be assumed to result in pipe severance and separation amounting to at least a one diameter lateral displacement of the ruptured piping sections unless physically limited by piping restraints, structural members, or piping stiffness as may be demonstrated by inelastic limit analysis (e.g., a plastic hinge in the piping is not developed under loading). In DCD Section 3.6.2.1.3.1, MHI stated that following a circumferential break, the two ends of the broken pipe are assumed to move clear of each other unless physically limited by piping restraints, structural members, or pipe stiffness. Clarify that piping stiffness is only used when it can be justified by inelastic limit analysis.

(c) BTP 3-4, Part B, Item C(i)(4) states for circumferential breaks that the dynamic

force of the jet discharge at the break location should be based on the effective cross-sectional flow area of the pipe and on a calculated fluid pressure as modified by an analytically or experimentally determined thrust coefficient. It further states that limited pipe displacement at the break location, line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs may be taken into account, as applicable, in the reduction of jet discharge. The staff noted that in DCD Section 3.6.2.1.3.1 MHI stated that the effective cross sectional (inside diameter) flow area of the pipe is used in the jet discharge evaluation. Clarify how the effective cross sectional flow area of the pipe is determined in the jet discharge evaluation.

(d) BTP 3-4, Part B, Item C(ii)(2) states that longitudinal breaks need not be postulated at terminal ends. Clarify whether this criterion is applicable to pipe break evaluation for APWR design.

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**ANSWER:**

(a) The break is postulated at piping weld and the description of the fourth paragraph of DCD Subsection 3.6.2.1.3.1 will be modified as described in BTP 3-4 Part B, Item C(i)(2).

(b) Yes, piping stiffness is used only when a plastic hinge is not developed in the piping.

(c) As specified in DCD Subsection 3.6.2.1.3.2, in longitudinal pipe breaks, the line restrictions, flow limiters, positive pump-controlled flow and the absence of energy reservoirs may be taken into account, as applicable. Similarly, in circumferential pipe breaks, the same items may be taken into account. The description will be added.

(d) The longitudinal breaks are not postulated at terminal ends as described in BTP 3-4 Part B, Item C(ii)(2). This description is missing from the DCD and it will be added.

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

(a) Replace the 4th paragraph of DCD Subsection 3.6.2.1.3.1 in its entirety with the following: "Where break locations are selected without the benefit of stress calculations, breaks are postulated at the piping welds to each fitting, valve, or welded attachment."

(b) There is no impact on the DCD.

(c) Add the following at end of the 4th paragraph of DCD Subsection 3.6.2.1.3.1: "The line restrictions, flow limiters, positive pump-controlled flow and the absence of energy reservoirs may be taken into account, as applicable."

(d) Add the following as the 3rd paragraph of DCD Subsection 3.6.2.1.3.2: "Longitudinal breaks need not be postulated at terminal ends."

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** **NO. 71-986 REVISION 0**

**SRP SECTION:** **03.06.02 - DETERMINATION OF RUPTURE LOCATIONS AND DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING**

**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-8**

BTP 3-4, Part B, Items A(ii)(3) and (6) provide the design requirements for guard pipes consistent with those specified in NRC Regulatory Guide (RG) 1.70. RG 1.70, Rev.3, Part 1, Section 3.6.2.4 defines that a guard pipe is a device to limit pressurization of the space between dual barriers of certain containments to acceptable levels. In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.2, MHI provided justification that the containment electrical and mechanical penetrations are designed with piping penetration compartments and therefore, no guard pipe assembly is required. It appears to the staff that the guard pipe assembly is functionally similar to the piping penetration compartments indicated in the DCD. Clarify if conditions specified in BTP 3-4, Part B, Items A (ii) (3) and (6) are also applicable to the piping penetrations shown in DCD Figure 3.8.1-8. Also, describe how the AWPR design meets the four specific criteria described in Section 3.6.2.4 of RG 1.70.

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**ANSWER:**

Since the PCCV penetrations are isolated in compartments made of concrete, guard pipes are not considered necessary around the PCCV penetration. Therefore, it is not considered necessary for this room to apply criteria of guard pipe, BTP 3-4 Part B Item A(ii)(3) and A(ii)(6).

**Impact on DCD**

There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-9**

SRP Section 3.6.2, Item III.2.A provides dynamic analysis criteria and discusses material capacity limitations for a crushable material type of whip restraint, while SRP Section 3.6.2, Item III.2.B discusses various methods of analyses. Also, ANSI/ANS-58.2-1988, Section 6.3 presents several different types of dynamic analysis methods. In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.3, MHI provided details regarding assumptions in the piping dynamic analysis. The staff noted that some blowdown forces are computed using a steady jet force based on ANS 58.2, while others, such as those for the Reactor Coolant System (RCS) piping, are computed using an MHI transient analysis with the MULTIFLEX code. Provide answers to the following:

(a) SRP Section 3.6.2, Item III.2.A states that for piping pressurized during normal operation at power, the initial condition should be the greater of the contained energy at hot standby or at 102% power. The staff did not find this assumption in the APWR DCD. Clarify if this is applicable to all approaches used for the APWR. If not, then provide technical justification for the alternate initial conditions to be assumed in the analyses.

(b) Acceptable dynamic models suggested in the SRP include lumped parameter analysis models, energy balance analysis models, and static analysis models. Also, alternate analytical approaches are discussed in ANS standard Sections 6.3.1 through 6.3.5. US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.3 presents only two specific approaches: steady state method and dynamic time-history analysis. Clarify if any other analytical (nonlinear) methods and modeling techniques (discussed in the SRP and ANS standard) will be used for APWR plants.

(c) Discuss acceptable procedures and computer programs to be used to calculate the pipe whip dynamic responses.

(d) Discuss the validation and verification (V/V) of the computer programs which the NRC staff has not yet approved. In particular, include V/V of the MULTIFLEX code discussed in DCD Tier 2 (Rev. 0) Section 3.9.2.5.2.

(e) There does not appear to be any consideration of how potential feedback between the jet and any nearby reflecting surface(s), which can increase substantially the dynamic jet forces impinging on the nearby target component and the dynamic thrust blowdown forces on the ruptured pipe through resonance, is considered. Provide details (with example, if available) that describe the methods including a description of how feedback amplification of dynamic blowdown forces will be considered for calculating the blowdown forcing functions at break locations and identify the computer program that will be used, if any.

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**ANSWER:**

(a) Yes, the initial condition should be the greater of the contained energy at hot standby or at 102% power. This description will be added to the DCD.

(b) The following references summarize other methodologies to be used as described in the SRP:

- DCD Subsections 3.6.2.4.2.1 and 3.6.2.4.2.3 describe the Complete System Dynamic Analysis
- DCD Subsection 3.6.2.4.2.2 describes the Energy Balance Analysis
- DCD Subsection 3.6.2.4.1 describes the Static Analysis

(c) The response of whip restraints used in US-APWR is computed by energy balance method described in DCD Subsection 3.6.2.4.2.2. No computer program is used.

(d) The computer programs used in the postulated pipe rupture analysis are as follows:

- MULTIFLEX: This code is used for the Reactor Coolant System blowdown analysis in LOCA and calculates the behavior of break flow and pressure wave in the primary system. It has been approved by NRC in WCAP-8709 in the past (Ref. 1).
- RELAP-5: This code is used for the blowdown analysis in the secondary side pipe rupture. The verification report will be provided.
- GOTHIC: This code is used for the subcompartment pressure analysis in the pipe rupture. The verification of this code is provided as a part of the subcompartment pressure analysis technical report (Ref. 2) submitted in February 2008.

- ANSYS: This code is used for reactor internal and reactor coolant loop structural analysis and calculates the loads acting on each structure. The verification of this code is performed according to ASME NQA-1 verification requirements.

  Reference 1) MULTIFLEX, A FORTRAN-IV Computer Program for Analyzing Thermal-Hydraulic-Structure System Dynamics. WCAP-8708 (proprietary), and WCAP-8709 (nonproprietary), September 1977.

  Reference 2) Subcompartment Analyses for US-APWR Design Confirmation, MUAP-07031-P (Rev. 0) (proprietary), and MUAP-07031-NP (Rev. 0) (nonproprietary), February 2008.

(e) Please refer to the answer of RAI 3.6.2-13. The response of RAI 3.6.2-13 will be made within 60 days after issuance of RAI.

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

(a) The following paragraph will be added at the end of DCD Subsection 3.6.3:

"The loading condition of a pipe run or branch, prior to the postulated rupture, in terms of internal pressure, temperature, and inertial effects are used in the evaluation for postulated breaks. For piping pressurized during operation at power, the initial condition is the greater of the contained energy at hot standby or at 102% power."

(b) There is no impact on the DCD.

(c) There is no impact on the DCD.

(d) There is no impact on the DCD.

(e) Please refer to the answer of RAI 3.6.2-13. The response of RAI 3.6.2-13 will be made within 60 days after issuance of RAI.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** **NO. 71-986 REVISION 0**

**SRP SECTION:** **03.06.02 - DETERMINATION OF RUPTURE LOCATIONS AND DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING**

**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-16**

In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.4.2, MHI discussed dynamic analysis of piping systems subject to pipe break loads to determine structural response of safety-related SSCs. After reviewing the methods discussed in this section, the staff noted that there are several items needing further clarifications as follows:

(a) As stated in Subsection 3.6.2.4.2.1, Appendix 3C provides methods used in the dynamic analysis of the reactor coolant loop (RCL) piping. There are two models: one coupled with the supporting structures and other involving the piping and its support systems. The dynamic analyses include the SSE loading only. No discussion of loads generated by postulated breaks from branch lines or RCL itself is found in this appendix. Provide the analysis methods for pipe break loads and the load combinations to be used.

(b) For components on the ruptured piping required for safe shutdown or that serve to protect the structural integrity of a safety-related component, SRP Section 3.9.3 provides the acceptance criteria for satisfying their functional operability. Discuss the criteria that will be used to ensure operability of pipe mounted safety-related components on the ruptured pipe.

(c) In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.4.2.2, MHI referred to Subsection 3.6.2 for design methodology of pipe whip restraints. It also states that when making a more detailed evaluation, the piping system and restraints can be modeled and a time history analysis performed. Neither details on this methodology (including load combinations) nor any sample calculations are provided to illustrate the methods to be used in the piping system design. Clarify the above statements.

**ANSWER:**

(a) Explanation of the following RCL pipe rupture analysis methods will be added to Appendix 3C.

- RCL structural analysis is performed for the postulated pipe rupture cases considering the applicable LBB criteria.
- Analysis methods apply time history direct integration or equivalent static analysis.
- External loads of pipe rupture, thrust loads, jet impingement loads, and subcompartment pressure loads are appropriately considered.
- The enveloping load is conservatively applied as the design load of the component.
- The combination of loads for Class 1 components and supports is discussed in DCD Subsection 3.9.3.1.3.

(b) DCD Subsection 3.6.2.1.1.1 describes that a five-way restraint is installed for main steam piping and feedwater piping outside of the PCCV to prevent a load from being applied to the CV isolation valve due to a postulated pipe break outside of break exclusion zone.

In other cases, the subject valve is installed sufficiently away from a postulated break location to prevent dynamic effects. Furthermore, the pipe stress in the vicinity of the valve is validated as very small by using a static force displacement methodology for the pipe displacement at the break location. This description will be added to DCD.

(c) The description in the last of paragraph of DCD Subsection 3.6.2.4.2.2, "When making a more detailed evaluation, the piping system and restraints can be modeled and a time history analysis performed" is to be modified as follows:

"When making a more detailed evaluation, the piping system and pipe whip restraints are modeled without taking credit for the supports designed using operational loads and a time history analysis."

**Impact on DCD**

The DCD will be changed in Revision 2 to incorporate the following:

(a) Replace the last paragraph in Appendix 3C, Section 3C.1, in its entirety with the following:

"RCL structural analysis is performed for the postulated pipe rupture cases considering the applicable LBB criteria. Analysis methods apply time history

direct integration or equivalent static analysis. External loads of pipe rupture, thrust loads, jet impingement loads, and subcompartment pressure loads are appropriately considered. The enveloping load is conservatively applied as the design load of the component. The combination of loads for Class 1 components and supports is discussed in DCD Subsection 3.9.3.1.3. Refer also to DCD Subsection 3.9.3.1 for additional discussion on the modeling of the RCL piping and support system."

(b) Add the following paragraphs to the end of DCD Subsection 3.6.2.4.2.2:

"The five-way restraint is installed for main steam piping and feedwater piping outside of the PCCV to prevent a load from being applied to the CV isolation valve due to a postulated pipe break outside of break exclusion zone.

In other cases, the subject valve is installed sufficiently away from a postulated break location to prevent dynamic effects. Furthermore, the pipe stress in the vicinity of the valve is validated as very small by using a static force displacement methodology for the pipe displacement at the break location."

(c) Replace the 7th paragraph of DCD Subsection 3.6.2.4.2.2 with the following:

"When making a more detailed evaluation, the piping system and pipe whip restraints are modeled without taking credit for the supports designed using operational loads and a time history analysis."

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**10/07/2008**

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**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** **NO. 71-986 REVISION 0**

**SRP SECTION:** **03.06.02 - DETERMINATION OF RUPTURE LOCATIONS AND DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING**

**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-17**

US-APWR DCD Tier 2 (Rev. 0) Section 3.6.2.4.4.1 states that pipe whip restraints are designed as seismic Category I components. Loads to be evaluated in combination with pipe break forces are Level A or B service loads and are not combined with seismic loads. In the evaluation of structures, loads producing primary stresses are used. The staff noted that this section presents analytical methods for the design and analysis of whip restraints. The staff also found that when the piping integrity is lost because of a postulated break, the pipe whip restraints act to limit the movement of the broken pipe to an acceptable distance and therefore, are considered as once-in-a-lifetime supports. These supports are typically non-ASME components and must remain functional following an earthquake up to and including the SSE. Clarify the statement that loads to be evaluated in combination with pipe break forces are Service Level A or B loads without a seismic load. Also, since pipe break forces are considered to be emergency and faulted conditions (Service Levels C and D) loads, discuss how the pipe break loads are included in the design of whip restraints, including the SSE.

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**ANSWER:**

Since pipe whip restraints used to protect SSCs are designed as seismic Category I as described in DCD Subsection 3.6.2.4.4.1, the pipe whip restraint can resist a single application of SSE. The evaluation to pipe break load is performed using the energy balance method, and the contribution due to random seismic load is not considered.

**Impact on DCD**

There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-18**

USAPWR Tier 1 Table 2.3-2, Piping Systems and Components Inspections, Tests, Analyses, and Acceptance Criteria, Item 6 states that the pipe break analysis report exists and concludes that, for each postulated piping failure, the reactor can be shut down safely and maintained in a safe, cold shutdown condition without offsite power. Also, in USAPWR DCD Tier 2, Section 3.6.4, the applicant identified several COL Information Items relating to pipe break evaluations. However, the DCD Tier 2, Section 3.6.3 does not contain a section that lists/summarizes the specific information that will be included in the pipe break analysis report. In addition, it does not address specifically when the COL applicant will submit the as-design pipe break analysis report that demonstrates the proper implementation of pipe break criteria by the COL applicant. The applicant is requested to identify a list of information that will be included in the pipe for including in the pipe break analysis report along with its completion schedule.

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**ANSWER:**

COL Item in Subsection 3.6.4 is modified in Revision 1.

Refer to UAP-HF-08123 for submittal dates of the as-design pipe break hazard analysis report. UAP-HF-08123 states that for ASME Class 1 piping, the report on risk significant piping will be issued in December 2010 and that the report for other piping will be issued prior to material procurement. For ASME Class 2 and 3 piping, UAP-HF-08123 states that the report for main steam piping will be issued in December 2010, that the report for risk significant piping will be issued in June 2012, and the report for other piping will be issued prior to material procurement.

**Impact on DCD**

There is no impact on the DCD.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**APPLICATION SECTION:** **3.6.2**

**DATE OF RAI ISSUE:** **09/09/2008**

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**QUESTION NO. : 03.06.02-19**

In US-APWR DCD Tier 2 (Rev. 0) Section 3.6.4, MHI stated that in COL 3.6(6) the COL applicant is to implement the criteria associated with special features, if any, in Subsection 3.6.2.5. The staff did not find any such Subsection 3.6.2.5 addressing special features in the DCD. Clarify this discrepancy.

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**ANSWER:**

Subsection 3.6.2.5 was inadvertently omitted in DCD Revision 0, and has been added to the DCD by Revision 1.

**Impact on DCD**

There is no impact beyond the addition of Subsection 3.6.2.5 by DCD Revision 1.

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.