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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-11451

Subject: **Amended MHI's Responses to US-APWR DCD RAI No. 71-986 Revision 0 (SRP 03.06.02)**

Reference: [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
[2]"MHI's Responses to US-APWR DCD RAI No. 71-986," UAP-HF-08226, dated October 7, 2008.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Amended Response to Request for additional Information No. 71-986 Revision 0". This amended response is submitted to reflect the discussion on telephone conference (2011/11/02).

Enclosure is the amended response to Question 03.06.02-2 of the RAI contained within Reference 1. The initial response was provided in Reference 2. MHI replaces the previous letters (Reference 2) with this amended response letter as for the response to Question 03.06.02-2.

This response is being submitted in two versions. One version (Enclosure 1) includes certain information, designated pursuant to the Commission guidance as sensitive unclassified non-safeguards information, referred to as security-related information ("SRI"), that is to be withheld from public disclosure under 10 C.F.R. § 2.390. The information that is SRI is identified by brackets. The second version (Enclosure 2) omits the SRI and is suitable for public disclosure. In the public version, the SRI is replaced by the designation "[Security-Related Information - Withheld under 10 CFR 2.390]."

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.

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NRO

Sincerely,

Hiroki Nishio for

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

Enclosure:

1. Amended Response to Request for Additional Information No. 71-986 Revision 0 (SRI included version)

2. Amended Response to Request for Additional Information No. 71-986 Revision 0 (SRI excluded version)

CC: J. A. Ciocco
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Enclosure 2

UAP-HF-11451
Docket Number 52-021

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

December, 2011

(SRI excluded version)

AMENDED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/27/2012

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: DCD SECTION 3.6.2

DATE OF RAI ISSUE: 09/09/2008

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.

ANSWER:

(Original Response dated October 7, 2008)

(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

(a) There is no impact on the DCD Revision 3.

(b) Additionally, the definition of break exclusion region in Main Steam Pipe Room was discussed in DCD Chapter 10 ACRS meeting. Based on the discussion with the NRC Section 3.6 staff, the following item will be revised for DCD Revision 3 to clarify the above definition (See Attachment):

Replace the first paragraph of Subsection 3.6.2.1.1.1, Application to Main Steam Pipe Room with:

- "No breaks are postulated in the main steam piping and main feedwater piping from the PCCV penetration outboard weld to the wall of main steam pipe room (Figure 3.6-1) by applying the following actions and meeting the above eight listed criteria"
- "However breaks are postulated in the branch piping connected to main steam piping and main feedwater piping in accordance with subsection 3.6.2.1.1.2."

Add the following sentence as the fourth bullet of Subsection 3.6.2.1.1.1, Application to Main Steam Pipe Room:

- "The length between the outboard isolation valve and the main steam pipe room wall is to be reduced to the minimum length practical"

Replace "Subsection 3.6.2.4.5" in the first paragraph of Subsection 3.6.2.4.2.2 with "Subsection 3.6.2.4.4.3".

Revise Figure 3.6-1 to include the approximate width of the main steam pipe room and specifically describe the location of main steam pipe room and reactor building.

(c) There is no impact on the DCD Revision 3.

(d) There is no impact on the DCD Revision 3.

(e) There is no impact on the DCD Revision 3.

(f) There is no impact on the DCD Revision 3.

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 Reports

There is no impact on a Technical / Topical Report.

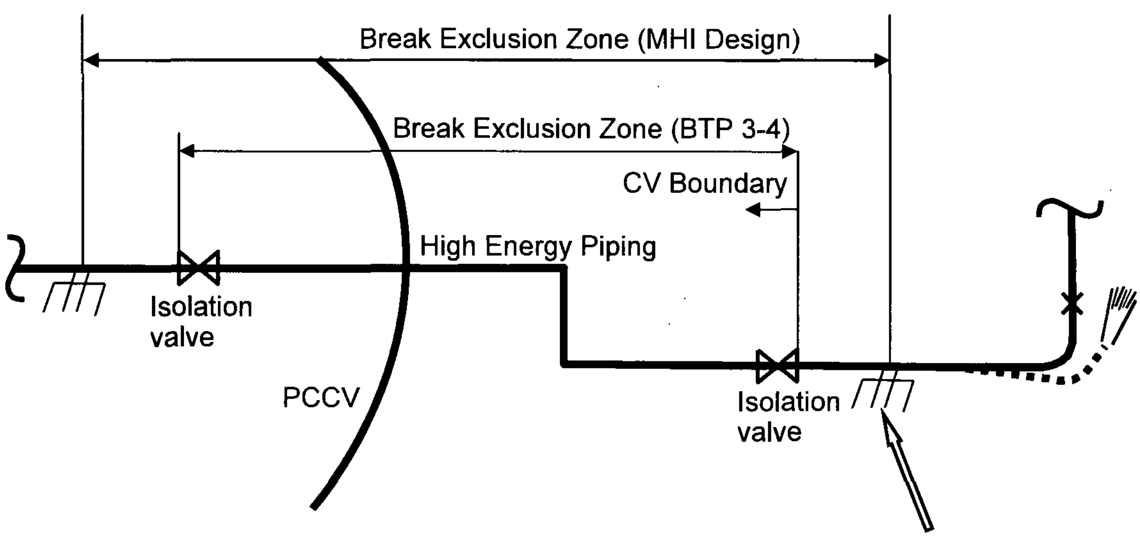
RAI 71-986 Question No. 03.06.02-2

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.

1. The design criteria of the ASME Code, Section III (Reference 3.6-10), Subarticle NE-1120, is satisfied for the PCCV penetration.

2. The maximum stress ranges as calculated by the sum of Equations 9 and 10 in Paragraph NC-3653 of ASME Code, Section III (Reference 3.6-9), considering those loads and conditions thereof for which Level A and Level B stress limits have been specified in the system's design specification, does not exceed 0.8(1.8 S_h + S_A). The S_h and S_A are allowable stresses at maximum (hot) temperature and allowable stress range for thermal expansion, respectively, as defined in Article NC-3600 of the ASME Code, Section III.

3. 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.

4. The number of circumferential and longitudinal piping welds and branch connections are minimized.

5. Welded attachments, for pipe supports or other purposes, to this portion of piping are 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 Subsection 3.6.2.1.1.2.

6. 100% volumetric examination in accordance with IWA-2400 of ASME Code, Section XI (Reference 3.6-11) of all piping welds is performed.

7. Anchors or five way restraints do not prevent the access required to conduct inservice examination specified in ASME Code, Section XI (Reference 3.6-11). ISI completed during each inspection interval provides examination of circumferential and longitudinal welds within the boundary of this portion of piping.

8. The length of these portions of piping is to be reduced to the minimum length practical.

<u>**Application to Main Steam Pipe Room**</u>

No breaks are postulated in the main steam <u>piping and main feedwater piping</u>~~supply system (MSS) and feedwater system (FWS) piping~~ from the PCCV penetration outboard weld to the wall of main steam pipe room (Figure 3.6-1) <u>by applying the following actions</u> DCD_03.06.02-2 and meeting the above eight listed criteria.provided the following actions are taken:. However, breaks are postulated in the branch piping connected to main steam piping and main feedwater piping in accordance with subsection 3.6.2.1.1.2. DCD_03.06.02-2

- The pipe is routed straight to lower the stresses.
- Five–way restraint (free only in axial direction) is installed in the main steam pipe room wall penetration.
- Essential equipment is protected from the environmental, flooding, and subcompartment pressurization effects of an assumed non-mechanistic longitudinal break. Each assumed non-mechanistic break has a cross sectional area of one square foot and postulated to occur at a location that has the greatest effect on essential equipment.
- The length between the outboard isolation valve and the main steam pipe room wall is to be reduced to the minimum length practical. DCD_03.06.02-2

3.6.2.1.1.2 Postulation of Pipe Breaks in Areas Other than PCCV Penetrations

The locations for postulated breaks in high-energy piping are dependent on the classification, quality group, and design standards used for the piping system. The break locations for high-energy piping are described in the following sections. These locations are postulated based on "as-designed" analyses using the design configuration. As a result of piping reanalysis, due to differences between the design configuration and the as-built configuration, the high stress and usage factor location may be shifted. The intermediate break (if any) locations need not be changed unless one of the following conditions exists:

a. The dynamic effects from the new (as-built) intermediate break locations are not mitigated by the original pipe whip restraint and jet shields.

b. There is significant change in pipe design parameters such as pipe size, wall thickness, or pressure rating.

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.

ASME Code, Section III, Division 1 – Class 1 Piping

Pipe breaks are postulated to occur at the following locations in piping and branch runs designed and constructed to the requirements for Class 1 piping in the ASME Code, Section III (Reference 3.6-12).

- At terminal ends of the piping, including the following:

to a stable flow downstream after the Mach Disk. The flow is so stable that disturbance at the impingement wall does not reach back to the Mach Disk.

When sub-cooled jet-flow impinges on the wall, pressure distributions on the wall are not of the concave type and a re-circulation vortex is not generated. This is due to having a flow velocity at the jet boundary that is lower than that of the core region.

Therefore, jet pressure oscillation does not have an impact on the design. Refer to Reference 3.6-32, Evaluation of Jet Impingement Issues Associated with Postulated Pipe Rupture, for details on assessing a jet pressure oscillation from a steam pipe break.

3.6.2.4.1.3 Jet Reflection Assessing Procedure

When jet flow impinges on a perpendicular wall, impinged jet flow is redirected and runs along the surface of the wall. The zone of influence obtained by computational fluid dynamics is enveloped by the estimated zone of influence from MHI original methodologies (Reference 3.6-25). Inside the zone of influence, impingement pressure includes effects of pressure due to flow parallel to an impingement wall. Loads due to jet impingement reflection outside of the zone of influence are considered so small that it is not necessary to be considered.

Therefore, jet reflection does not have an impact on the design. Refer to Reference 3.6-32, Evaluation of Jet Impingement Issues Associated with Postulated Pipe Rupture, for details on assessing a jet reflection.

3.6.2.4.2 Dynamic Analysis for Piping Systems

3.6.2.4.2.1 RCL Piping

Appendix 3C provides analysis details for RCL piping. Loads generated by postulated breaks from branch lines are applied to determine structural response of RCL piping.

3.6.2.4.2.2 Piping Other Than RCL Piping

In evaluating the dynamic effects of breaks in high-energy-fluid system piping other than RCL piping, possible break locations and break configurations are first established based on Subsection 3.6.2.1 and the effects of pipe whipping are then evaluated based on Subsection ~~3.6.2.4.5.~~3.6.2.4.4.3 DCD_03.06.02-2

If the above evaluation determines that no safety-related SSCs are damaged, then dynamic analysis is not necessary. If the above evaluation determines that the structural integrity of safety-related SSCs is impaired, pipe whip restraints are incorporated in the high-energy-fluid system piping of concern and dynamic analysis is conducted for the system including the piping and the pipe whip restraints.

In general, a gap is provided between a pipe whip restraint and pipe so as not to restrict thermal movement in the pipe. In the event of a pipe-break accident, the pipe accelerates in the gap due to the jet force and collides with the pipe whip restraint. The dynamic effects of this pipe and pipe whip restraint are usually evaluated by the energy balance method.

DCD_03.06.02-2

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Figure 3.6-1 Break Exclusion Region- Main Steam Pipe Room