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

November 24, 2010

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-10319

Subject: MHI's Responses to US-APWR DCD RAI No. 636-4732 (SPR 03.06.02)

Reference: 1) "Request for Additional Information No. 636-4732 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," dated 9/23/2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 636-4732, Revision 0."

Enclosed are the responses to RAI 636-4732, Questions 40-48 that are contained within Reference 1. This transmittal completes the response to this RAI.

As indicated in the enclosed materials, this document contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. A non-proprietary version of the document is also being submitted with the information identified as proprietary redacted and replaced by the designation "[ ]".

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

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

Sincerely,

Y. Ogata

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

D081
NRO

Enclosures:

1. Affidavit of Yoshiki Ogata

2. Responses to Request for Additional Information No. 636-4732, Revision 0 (Proprietary)

3. Responses to Request for Additional Information No. 636-4732, Revision 0 (Non-Proprietary)

CC: J. A. Ciocco
C. K. Paulson

Contact Information
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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-10319

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, LTD ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "Responses to Request for Additional Information No. 636-4732, Revision 0," and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. All pages contain proprietary information as identified with the label "Proprietary" on the top of the page, and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information identified as proprietary in the enclosed documents has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the unique design and methodology developed by MHI for performing the plant design of protection against postulated piping failures.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market:

A. Loss of competitive advantage due to the costs associated with the development of the methodology related to the analysis.

B. Loss of competitive advantage of the US-APWR created by the benefits of the approach to jet expansion modeling that maintains the desired level of conservatism.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed on this 24th day of Nobember, 2010.

Y. Ogata

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

Enclosure 3

UAP-HF-10319
Docket No. 52-021

Responses to Request for Additional Information No. 636-4732,
Revision 0

November, 2010
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-40

Follow-up RAI 03.06.02-10 S02

This is the supplemental RAI for RAI 71-986, 03.06.02-10 and RAI 459-3331, 03.06.02-29

In its response to the staff's RAI, the applicant continues to assert that the pressures induced by blast waves on surrounding structures in US-APWR plants will be negligible. In its justification, the applicant ignores the effects of surrounding structures and walls, and the pressure wave reflections they would cause. The applicant also assumed that the blast wave loading time history is a step function, rising from ambient pressure to a peak pressure and remaining at the peak pressure indefinitely. In actuality, blast wave pressure time histories will peak, and then decrease. More importantly, this is generally followed by shock reflections, pressure increases and subsequent expansions, often to pressures below ambient pressure. The applicant also considers only barrier structures, and resonance frequencies below 50 Hz, in their response. The applicant is advised that the staff is concerned about not only barrier structures, but other structures, and safety-related components and systems. The staff is also concerned about all structural resonances which could be strongly excited by blast waves, not only the fundamental modes. The applicant is requested again to provide a rigorous explanation of appropriate and conservative blast wave estimating procedures to be applied to the USAPWR design and to document those procedures in a revised version of the DCD.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 439-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-41

Follow-up RAI 03.06.02-11(a) S02

This is the supplemental RAI for RAI 71-986, 03.06.02-11(a) and RAI 459-3331, 03.06.02-30

In its response to the staff's RAI, the applicant continues to use ANS 58.2 to assess jet impingement loading on US-APWR structures and components. It should be noted that several inaccuracies in the ANS 58.2 Standard are identified and the Standard is no longer considered universally acceptable for jet impingement loading evaluation by the staff. Although the applicant cites several papers that contain experimental data from tests conducted in Japan, it does not appear that the applicant uses those data to define their jet impingement loads, nor to justify using ANS 58.2 methodology/procedures. The applicant is therefore requested again to substantiate that the use of ANS 58.2 methodology/procedures in US-APWR application is conservative. The applicant may submit different procedures (perhaps using the measurements cited in MHI references 1-6), along with substantiation that those procedures are conservative.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

The jet geometry evaluation is performed with MHI methods while thrust force evaluation is based on ANS 58.2. This clarification will be reflected in Revision 3 of the DCD.

Impact on DCD

See Attachment 3 for the mark-up of DCD Tier 2, Section 3.6, changes to be incorporated:

- The 2nd paragraph in DCD Subsection 3.6.2.3 will be modified as follows:

  "The analytical methods used for the calculation of the jet thrust for the above described situations are based on SRP 3.6.2 (Reference 3.6-3) and MHI original methodologies based on measurements cited in References 3.6-25, 3.6-26, 3.6-27, 3.6-28, 3.6-29 and 3.6-30."

- The 3rd paragraph in DCD Subsection 3.6.2.4.1 will be modified as follows:

  "The MHI original methodologies (Reference 3.6-25) used to evaluate the jet effects resulting from the postulated breaks in high energy piping are based on measurements cited in References 3.6-26, 3.6-27, 3.6-28, 3.6-29, 3.6-30 and 3.6-31. Figure 3.6-2 depicts jet characteristics for the three fluid states. The short term response evaluates the jet impingement load considering a dynamic load factor of 2 and snubber supports to be active. No dynamic load factor is used and the snubbers are considered inactive for the long-term response."

- Add the following at the end of DCD Subsection 3.6.5:

  "3.6-25 MUAP-10017 Revision 1 "US-APWR Methodology of Pipe Break Hazard Analysis"

  3.6-26 Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Study of Pipe Reaction Force and Jet Impingement Load at the Pipe Break, Trans. 5th Int. Conf. on SMiRT, F6/2, 1979.

  3.6-27 Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Studies on Transient Water-Steam Impinging Jet, Vol. 22 No. 5, pp. 403-409, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

  3.6-28 Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Studies on Steam Free Jet and Impinging Jet, Vol. 22 No. 9, pp. 634-640, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

  3.6-29 Masuda, F., Nakatogawa, T., Kawanishi, K. and Isono, M., Experimental Study on an Impingement High-Pressure Steam Jet, Nuclear Engineering and Design 67-2, pgs 273-285, 1982.

  3.6-30 Masuda, F., Nakatogawa, T., Kawanishi, K. and Isono, M., Experimental Study on Jets Formed Under Discharges of High-Pressure Subcooled

Water and Steam-Water Mixture, Trans. 7th Int. Conf. on SMiRT, F1/6, 1983.

3.6-31 Isozaki, T. and Miyazono, S., Experimental Study of Jet Discharging Test Results under BWR and PWR Loss of Coolant Accident Conditions, Nuclear Engineering and Design 96, 1986."

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-42

Follow-up RAI 03.06.02-12(a) S02

This is the supplemental RAI for RAI 71-986, 03.06.02-12(a) and RAI 459-3331, 03.06.02-31

In its response to RAI 459-3331, 03.06.02-31, the applicant agrees that the pressure distribution is non-uniform. The applicant also states that it will uniformly use the maximum pressure in their non-uniform pressure distribution, which is conservative. However, the applicant did not include this commitment in a revision to the DCD. The applicant is requested to document their commitment to use the maximum pressure in its assumed uniform pressure distribution in a revised version of the DCD.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

The 2nd paragraph of DCD Subsection 3.6.2.4.1 will be modified in Revision 3 of the DCD to use the maximum pressure as an assumed uniform pressure distribution.

Impact on DCD

See Attachment 3 for the mark-up of DCD Tier 2, Section 3.6, changes to be incorporated:

- Add the following at end of the 2nd paragraph of DCD Subsection 3.6.2.4.1:

  "The Jet impingement pressure essentially has non-uniform distributions, which varies with distance from the pipe break as shown in References 3.6-26, 3.6-27, 3.6-28, 3.6-29, 3.6-30 and 3.6-31. However, the maximum pressure in the non-uniform distribution is conservatively used as uniform distribution."

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-43

Follow-up RAI 03.06.02-12(b) S02

This is the supplemental RAI for RAI 71-986, 03.06.02-12(b) and RAI 459-3331, 03.06.02-32

In RAI 459-3331, 03.06.02-32, the staff requested the applicant to expand on a table provided by the applicant in its previous RAI response to include all postulated pipe break locations, along with internal and external properties and the analysis approach to be used for the jet impingement load evaluation. In its response to this RAI, the applicant provided the requested table. However, the applicant did not include this table in a revision to the DCD. The applicant is therefore requested to include this table in a revised version of the DCD.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

Table 3.6-2, providing all postulated pipe break locations, internal and external properties and the analysis approach to be used for the jet impingement load evaluation, will be included in Revision 3 of the DCD.

Impact on DCD

See Attachment 4 for the mark-up of DCD Tier 2, Section 3.6, changes to be incorporated:

- Add the Table 3.6-2, "List of High Energy Lines for Pipe Break Hazard Analysis, Including Properties of Internal and External Fluids," behind Table 3.6-1 in DCD Section 3.6.

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-44

Follow-up RAI 03.06.02-13 S02

This is the supplemental RAI for RAI 71-986, 03.06.02-13 and RAI 459-3331, 03.06.02-33

In its response to the staff's RAI, the applicant discounts the possibility of feedback amplification of dynamic jet loads on the grounds that the sound speed within the jet plumes of two-phase flows is much smaller than the sound speed outside the plumes. However, the acoustic waves which cause feedback and the amplification of shed vortices from the pipe break propagate outside the jet plume at the sound speed of the external, quiescent fluid (Ho and Nossier, 1981), and are not strongly affected by the sound speed within the jet plume. Thus, even supersonic jets have similar feedback mechanisms. The applicant is therefore requested to provide a conservative methodology for assessing jet impingement loading at resonant jet conditions. The applicant is also requested to provide a conservative methodology for assessing the effects of jet impingement loading oscillations at non-resonant conditions (without strong feedback amplification), and a methodology for assessing the effects of oscillating jet loads on impinged-upon structures. Furthermore, the applicant is requested to document these methodologies in a revision of the DCD.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

References

1. A. Dauptain, B. Cuenot, and L.Y.M Gicquel , Large Eddy Simulation of a Stable Supersonic Jet Impinging on Flat Plate, Cerfacs, 42 ave. G. Coriolis 31057 Toulouse-France.

1. S. I. Kim, S. O. Park, Oscillatory Behavior of Super Sonic Impinging Jet Flows Shock Waves, 2005,14(4), pp. 259-272.

2. Nakatogawa, T., Masuda, F., Kawanishi, K., Isono, M., High Pressure Water-Steam Impinging Jet Characteristic , Vol. 24 No. 10, pp. 817-825, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

3. Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Studies on Steam Free Jet and Impinging Jet, Vol. 22 No. 9, pp. 634-640, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

5. Jennifer A. (Wilkes) Inman, Paul M. Danehy, Robert J. Nowak, and David W. Alderfer, Fluorescence Imaging Study of Impinging Underexpanded Jets, NASA Langley Research Center, Hampton VA, 23681-2199

6. Donaldson, C.D., Snedker, R.S., J.Fluid Mech., 45, Pt. 2 (1971).

7. Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Studies on Transient Water-Steam Impinging Jet, Vol. 22 No. 5, pp. 343-349, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

8. Okada, H. and Minato, A., the Japan Nuclear Energy Safety (JNES) paper titled Application of Compressible Two-Fluid Mode Code to Supersonic Two-Phase Jet Flow Analysis, The 13th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-13) N13P1368 Kanazawa City, Ishikawa Prefecture, Japan, September 27-October 2, 2009.

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-45

Follow-up RAI 03.06.02-14 S02

This is the supplemental RAI for RAI 71-986, 03.06.02-14 and RAI 459-3331, 03.06.02-34

In its response to the staff's RAI, the applicant stated that jet reflection effects would be "assessed considering the changes in direction and expansion with decaying by distance." This response is vague, and does not constitute a substantiated, conservative approach for assessing the effects of jet reflections. Also, the applicant has not documented an approach for jet reflection assessment in a revision of the DCD.
The applicant is therefore requested to provide a jet reflection assessment approach and to document it in a DCD revision.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

Reference:
1 N. Najaratonam, Jet Flow, Morikita, p223

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-46

Follow-up RAI 03.06.02-15 S02

This is the supplemental RAI for RAI 71-986, 03.06.02-15 and RAI 459-3331, 03.06.02-35

In its response to the staff's RAI, the applicant references the response to RAI 03.06.02-28. In that response, the applicant discounts the possibility of feedback amplification of dynamic jet loads on the grounds that the sound speed within the jet plumes of two-phase flows is much smaller than the sound speed outside the plumes. However, the acoustic waves which cause feedback and the amplification of shed vortices from the pipe break propagate outside the jet plume at the sound speed of the external, quiescent fluid (Ho and Nossier, 1981), and are not strongly affected by the sound speed within the jet plume. The applicant is therefore requested to provide a conservative methodology for assessing jet impingement loading on shields and barriers at resonant jet conditions and to document the methodology in a revision of the DCD.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08258; dated November 7, 2008; ML083180225.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

ANSWER:

Refer to the answer the RAI question No. 03.06.02-44.

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-47

Follow-up RAI 03.06.02-6 S01

This is the supplemental RAI for RAI 71-986, 03.06.02-6

In its response to the staff's RAI, the applicant stated that the BTP 3-4, Part B, Item B(iii)(1)(b) criterion will be added to Revision 2 of USAPWR DCD Subsection 3.6.2.1.2.2. The staff reviewed this subsection of Revision 2 of DCD and found that the information in the DCD is not consistent with the BTP requirement. Specifically, it should state that leakage cracks are postulated for ASME Code, Section III, Class 1 piping systems, where the stress range calculated by Eq. (10) in NB-3653 is more than (as opposed to "less than" as stated in DCD) 1.2 Sm. The applicant is therefore requested to make this correction in the next revision of the DCD.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08226; dated October 7, 2008; ML082840135.

ANSWER:

The phrase "less than" in the first bullet of the first paragraph of DCD Subsection 3.6.2.1.2.2 will be corrected to "more than" in Revision 3 of the DCD.

Impact on DCD

See Attachment 5 for the mark-up of DCD Tier 2, Section 3.6, changes to be incorporated:

- Change the first bullet of the first paragraph of DCD Subsection 3.6.2.1.2.2 to:

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

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

11/24/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 636-4732 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: **09/23/2010**

QUESTION NO. : 03.06.02-48

Follow-up RAI 03.06.02-39 S01

This is the supplemental RAI for RAI 71-986, 03.06.02-18 and RAI 459-3331, 03.06.02-39

The applicant did not adequately address the staff's concerns included in RAI 459-3331, 03.06.02-39. In that RAI, the applicant was requested to include a description in DCD Tier 2 Section 3.6.2 that clearly outlines the information that will be included in the pipe break hazard analysis report along with its (as-design aspect) closure milestone. The applicant was also requested to clarify that pipe break hazard analysis will be performed for all the piping systems (including the non-safety class piping) that are within the scope of SRP Section 3.6.2.

In its RAI response, the applicant provides a list of information under a proposed new DCD Section 3.6.2.6, Pipe Break Hazard Analysis Methodology. However, the staff found that the title of that DCD subsection, "Pipe Break Hazard Analysis Methodology", is not consistent with the content of that subsection. Specifically, DCD Section 3.6.2.6 outlines the information that will be included in the pipe break hazard analysis report rather than pipe break hazard analysis methodology. In addition, the third bullet, identification of SSCs that are safety-related or required for safe shutdown, included in that list of information needs clarification that for each postulated pipe break/crack location, the applicant will identify (in the pipe break hazard analysis report) all the safety-related or required for safe shutdown that are in close proximity to the postulated pipe rupture. Furthermore, the applicant is again requested to clarify that pipe break hazard analysis will be performed for all the piping systems (including the non-safety class piping) that are within the scope of SRP Section 3.6.2. The applicant is requested to address these staff's concerns.

In its RAI response, the applicant proposed some changes to DCD Tier 1, Section 2.3. Specifically, the applicant proposed changes to Items 4 and 5 in Table 2.3-2 to include both as-designed and as-built aspects of pipe break hazard analysis. However, the applicant referred to "reports" for both aspects of the pipe break hazard analysis report. It does not make it clear that both as-designed and as-built pipe break analysis will contain all the information as outlined in DCD Tier 2 Section 3.6.2.6. As a minimum, the title of Section 3.6.2.6 (after it is revised to address the staff's concern identified in the second paragraph of this RAI) should be used in the ITAAC table. In addition, the ITAAC should make clear that Item 4 is for the as-designed plant while Item 5 is for the as-built reconciliation respectively and for both aspects, the pipe break hazard analysis performed will be clearly documented in the pipe break hazard analysis report. Furthermore, both DCD Section 3.6.2.6 and ITAAC Table 2.3-2 need to make it clear that pipe break hazard analysis will be performed for all the piping systems (including the non-safety class piping) that are within the scope of SRP Section 3.6.2. Finally, the current description of design commitment and acceptance criteria for the as-built aspect of pipe break hazard analysis is not clear. It needs to make it clear that the as-built pipe break analysis is to be reconciled with the as-designed pipe break hazard analysis. Also, the as-built pipe break analysis is to be performed for both high energy and moderate energy piping to ensure that the as-built safety related SSCs are appropriately protected against or qualified to withstand the dynamic and the environmental effects associated with postulated failures for all the piping systems (including the non-safety class piping) that are within the scope of SRP Section 3.6.2. The applicant is requested to address these staff's concerns.

Lastly, the applicant did not clearly address staff's concern concerning the closure milestone for as-designed pipe break hazard analysis report. The applicant is requested to clarify whether the MHI's design completion plan as described in UAP-HF-08123 is still valid. Also, in that plan, the applicant did not include the completion schedule for all the piping systems (including the non-safety class piping) that are within the scope of SRP Section 3.6.2.

References:

MHI's Response to US-APWR DCD RAI No. 71-986; MHI Ref: UAP-HF-08226; dated October 7, 2008; ML082840135.

MHI's Responses to US-APWR DCD RAI No. 459-3331; MHI Ref: UAP-HF-09542; dated December 1, 2009; ML093370091.

Additional Information for Design Completion Plan of US-APWR Piping Systems and Components; MHI Ref: UAP-HF-08123; dated July 14, 2008; ML082030589.

ANSWER:

- Subsection Title

MHI will correct the title of Subsection 3.6.2.6 to "Outline of Pipe Break Hazard Analysis Reports" in Revision 3 of the DCD.

- Identification of SSCs

MHI identifies in the pipe break hazard analysis report all the safety-related components or components required for safe shutdown that are in close proximity to the pipe rupture. This clarification will be added to the third bullet in Subsection 3.6.2.6 in Revision 3 of the DCD.

- Pipe Break Hazard Analysis for All Piping Systems

MHI will clarify in Revision 3 of DCD Subsection 3.6.2.6 and Tier 1 ITAAC, Table 2.3-2, that pipe-break hazard analyses are performed on all piping systems (including the non-safety class piping).

- Analysis Report

MHI will prepare the "as-designed pipe-break analysis report" and "as-built pipe-break analysis report" to contain all the information as outlined in DCD Tier 2, Subsection 3.6.2.6. This clarification will be included in Subsection 3.6.2.6 in Revision 3 of the DCD.

- Moderate Energy Piping

MHI will clarify in Revision 3 of DCD Tier 1 ITAAC, Table 2.3-2, that the as-built pipe break analysis is to be performed for both high energy and moderate energy piping.

- Milestone

The design completion plan described in UAP-HF-08123 is not valid. The updated design completion plan was provided in MHI Letter UAP-HF-10207.

The completion schedule for all piping systems, including the non-safety class piping, that are within the scope of SRP Section 3.6.2, is completed prior to material procurement.

Impact on DCD

See Attachment 6 for the mark-up of DCD Tier 2, Section 3.6, changes to be incorporated:

- The DCD Subsection 3.6.2.6 will be added as follows:

"3.6.2.6 Outline of Pipe Break Hazard Analysis Report(s)

The following information is outline of methodology for the pipe break hazard analysis that will be completed for all the piping systems (including the non-safety class piping) in accordance with closure of Inspections, Tests, Analyses and Acceptance Criteria (ITAAC) Tier 1, Table 2.3-2 related to pipe break hazard analysis report:

- Identification of pipe break locations in high energy piping[1]

- Identification of leakage crack locations in high and moderate energy piping
- Identification of SSCs that are safety-related or required for safe shutdown[2]
- Evaluation of consequences of pipe whip and jet impingement
- Evaluation of consequences of spray wetting, flooding, environmental conditions
- Design and location of protective barriers, restraints, and enclosures

Notes

1. Table 3.6-2 shows the list of high energy lines for pipe break hazard analysis, including properties of internal and external fluids.
2. All the SSCs that are safety-related or required for safe shutdown in close proximity to the postulated pipe rupture will be identified."

- The DCD Tier 1 ITAAC, Table 2.3-2 will be modified as follows:

Table 2.3-2 Piping Systems and Components Inspections, Tests, Analyses, and Acceptance Criteria (Sheet 2 of 2)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
4. Safety-related SSCs are designed to be protected against or qualified to withstand the dynamic and environmental effects associated with analyses of postulated failures for all the piping systems (including the non-safety class piping).	4.i Dynamic effect analysis will be performed for the high-energy piping system. The analysis includes the evaluation of pipe whip and jet impingement.	4.i Pipe break hazard analysis report(s) for all high-energy piping system exist and conclude that for each postulated piping failure, the reactor can be shut down safely and maintained in a safe, cold shutdown condition without offsite power. The report confirms whether: (A) piping stresses in the containment penetration area are within allowable stress limits, (B) pipe whip restraints and jet shield designs can mitigate pipe break loads, and (C) loads on safety-related SSCs are within design load limits.
	4.ii Environmental effect analysis will be performed for the high-energy piping and moderate-energy piping systems. The analysis includes the evaluation for spray wetting, flooding, and environmental conditions, as appropriate.	4.ii Pipe break hazard analysis report(s) for all high-energy piping and moderate-energy piping systems exist and conclude that for each postulated piping failure, the reactor can be shut down safely and maintained in a safe, cold shutdown condition without offsite power. The report confirms whether SSCs are protected or qualified to withstand the environmental effects of postulated failures.
5. Safety-related SSCs are reconciled with the analyses results of as-designed pipe break hazard analysis report(s).	5. A reconciliation analysis of the as-built high-energy piping and moderate-energy piping using as-designed pipe break hazard analysis report(s) and as-built information will be performed.	5. Pipe break hazard analysis report(s) exist and conclude that the as-built high-energy piping systems including the protective features and moderate-energy piping systems are installed in the as-built plant as described in the as-designed pipe break hazard analysis report(s).

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

This completes MHI's responses to the NRC's questions.

Leakage cracks are not postulated in 1-inch nominal diameter and smaller piping.

Leakage cracks are postulated in those circumferential directions that result in the most severe environmental, spray wetting, and flooding consequences.

Fluid flow from leakage cracks is based on a circular orifice with a cross-sectional area equal to that of a rectangle one-half the pipe inside diameter in length and one-half the pipe wall thickness in width. The flow from the crack opening is assumed to result in an environment that wets all unprotected components within the compartment, with consequent flooding in the compartment and communicating compartments based on conservatively estimated time period to effect corrective actions.

3.6.2.2 Guard Pipe Assembly Design Criteria

Piping penetrations are an integral part of the PCCV pressure boundary. The annular space of the US-APWR consists of multiple compartments encircling the PCCV. These compartments segregate the PCCV electrical and mechanical penetrations into their own isolated compartments; specifically, electrical penetration rooms and mechanical penetration rooms. By virtue of the plant configuration, as piping crosses from inside to outside the PCCV, it emerges into piping penetration compartments. These compartments are designed to address postulated piping failures and the effect there of, as such, guard pipe assemblies are not required.

3.6.2.3 Analytic Methods to Define Forcing Functions and Response Models

The rupture of a pressurized pipe causes the flow characteristics of the system to change, creating reaction forces that can dynamically excite the piping system. To determine the forcing function for breaks postulated based on the criteria in Subsection 3.6.2.1, the fluid conditions at the upstream source and at the break exit determine the analytical approach. For most applications, one of the following situations exists.

- Superheated or saturated steam
- Saturated or sub-cooled water
- Cold water (non-flashing)

The analytical methods used for the calculation of the jet thrust for the above described situations are based on SRP 3.6.2 (Reference 3.6-3) and MHI original methodologies (Reference 3.6-25) based on measurements cited in References 3.6-26, 3.6-27, 3.6-28, 3.6-29, 3.6-30 and 3.6-31 ~~ANSI/ANS 58.2-1988 (Reference 3.6-14)~~.

The time dependent forcing function is effected by the thrust pulse resulting from the sudden pressure drop at the initial moment of pipe rupture, the thrust transient resulting from wave propagation and reflection, and the blowdown thrust resulting from the buildup of the discharge flow rate, which may reach a steady state if there is fluid energy reservoir having sufficient capacity to develop a steady jet for a significant interval.

Alternatively, a steady state jet thrust function may be used as outlined in Subsection 3.6.2.3.1.

A rise time of one millisecond is used for the initial pulse.

streamline force node orientation in the system. The flow areas and projection coefficients are described along the three axes of the global coordinate system. Each node is described by one or two flow apertures as a separate control volume. Forces are broken down orthogonally into x, y, and z components. The summation of the total number of apertures results in orthogonal thrust forces F_x, F_y, and F_z. These thrust forces are applied as input in dynamic analyses of piping and restraints.

3.6.2.4 Dynamic Analysis Methods to Verify Integrity and Operability

Time dependent and steady state thrust reaction loads caused by saturated or superheated steam, saturated or sub-cooled water, and cold water (non-flashing) fluid from a ruptured pipe are used in the analyses of dynamic effects of pipe breaks.

3.6.2.4.1 Jet Impingement Loading on Safety-Related Components

Structural integrity of safety-related SSCs against jet impingement load caused by pipe break is evaluated based on steady state jet force from Subsection 3.6.2.3.

Jet impingement loading is a suddenly applied constant load which can have significant energy content. These loads are generally treated as statically applied loads. The Jet impingement pressure essentially has non-uniform distributions, which varies with distance from the pipe break as shown in References 3.6-26, 3.6-27, 3.6-28, 3.6-29, 3.6-30 and 3.6-31. However, the maximum pressure in the non-uniform distribution is conservatively used as uniform distribution.

The MHI original methodologies (Reference 3.6-25) ~~methods~~ used to evaluate the jet effects resulting from the postulated breaks in high energy piping are based on measurements cited in References 3.6-26, 3.6-27, 3.6-28, 3.6-29, 3.6-30 and 3.6-31~~described in Appendices C and D of ANSI/ANS 58.2 (Reference 3.6-14)~~. Figure 3.6-2 depicts jet characteristics for the three fluid states. The short term response evaluates the jet impingement load considering a dynamic load factor of 2 and snubber supports to be active. No dynamic load factor is used and the snubbers are considered inactive for the long-term response.

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.

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

3.6-20 Report of the ASCE Committee on Impactive and Impulsive Loads. Second ASCE Conference on Civil Engineering and Nuclear Power, Volume V, 1980.

3.6-21 Reactor Coolant Pressure Boundary Leakage Detection Systems. Regulatory Guide 1.45, U.S. Nuclear Regulatory Commission, Washington, DC, May 1973.

3.6-22 Control of the Use of Sensitized Stainless Steel. Regulatory Guide 1.44, U.S. Nuclear Regulatory Commission, Washington, DC, May 1973.

3.6-23 Evaluation of Potential Pipe Breaks, NUREG-1061, Vol. 3, U.S. Nuclear Regulatory Commission Piping Review Committee, November 1984.

3.6-24 US-APWR Leak-Before-Break Evaluation. MHI Technical Report, Later.

3.6-25 MUAP-10017 Revision 1 "US-APWR Methodology of Pipe Break Hazard Analysis"

3.6-26 Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Study of Pipe Reaction Force and Jet Impingement Load at the Pipe Break, Trans. 5th Int. Conf. on SMiRT, F6/2, 1979.

3.6-27 Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Studies on Transient Water-Steam Impinging Jet, Vol. 22 No. 5, pp. 403-409, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

3.6-28 Kitade, K., Nakatogawa, T., Nishikawa, H., Kawanishi, K., and Tsuruto, C., Experimental Studies on Steam Free Jet and Impinging Jet, Vol. 22 No. 9, pp. 634-640, Journal of Atomic Energy Society of Japan, 1980 (in Japanese).

3.6-29 Masuda, F., Nakatogawa, T., Kawanishi, K. and Isono, M., Experimental Study on an Impingement High-Pressure Steam Jet, Nuclear Engineering and Design 67-2, pgs 273-285, 1982.

3.6-30 Masuda, F., Nakatogawa, T., Kawanishi, K. and Isono, M., Experimental Study on Jets Formed Under Discharges of High-Pressure Subcooled Water and Steam-Water Mixture, Trans. 7th Int. Conf. on SMiRT, F1/6, 1983.

3.6-31 Isozaki, T. and Miyazono, S., Experimental Study of Jet Discharging Test Results under BWR and PWR Loss of Coolant Accident Conditions, Nuclear Engineering and Design 96, 1986.

ATTACHMENT 4
to RAI 636-4732

Table 3.6-2

List of High Energy Lines for Pipe Break Hazard Analysis, Including Properties of Internal and External Fluids

No.	System	Subsystem	Line No(s)	Nominal Diameter (Inches)	Outside Diameter (Inches)	Thickness (Inches)	Material	Temp (°F)	Pressure (psig)	Inside Pipe	Outside Pipe (°F , psig)
1	RCS	Primary Loop Hot Leg	31"ID-RCS-2501R A,B,C,D	31ID	37.12	3.06	SA182 F316	617	2235	Subcooled liquid	Air (120, 0)
1	RCS	Primary Loop Hot Leg	31"ID-RCS-2501R A,B,C,D	31ID	37.12	3.06	SA182 F316LN	617	2235	Subcooled liquid	Air (120, 0)
2	RCS	Primary Loop Crossover Leg	31"ID-RCS-2501R A,B,C,D	31ID	37.12	3.06	SA182 F316	550.6	2235	Subcooled liquid	Air (120, 0)
3	RCS	Primary Loop Cold Leg	31"ID-RCS-2501R A,B,C,D	31ID	37.12	3.06	SA182 F316	550.6	2235	Subcooled liquid	
2	RCS	Primary Loop Crossover Leg	31"ID-RCS-2501R A,B,C,D	31ID	37.12	3.06	SA182 F316LN	550.6	2235	Subcooled liquid	Air (120, 0)
3	RCS	Primary Loop Cold Leg	31"ID-RCS-2501R A,B,C,D	31ID	37.12	3.06	SA182 F316LN	550.6	2235	Subcooled liquid	
4	RCS	Surge Line	16"-RCS-2501R B	16	16	1.594	SA-312 TP316	653	2235	Saturated liquid	Air (120, 0)
5	RCS	Surge Line	16"-RCS-2501R A	16	16	1.594	SA-312 TP316	449	400	Saturated liquid	Air (120, 0)
6	RCS	Residual Heat Removal System (RHRS) Hot Leg Branch Line off RCS	10"-RCS-2501R A,B,C,D, Hot Leg Side	10	10.75	1.125	SA-312 TP316	617	2235	Subcooled liquid	Air (120, 0)
7	RCS	RHRS Cold Leg Branch Line off RCS	8"- RCS -2501R A,B,C,D (COLD LEG)	8	8.625	0.906	SA-312 TP316	550.6	2235	Subcooled liquid	Air (120, 0)
8	SIS	Accumulator System	14"-RCS-2501R A,B,C,D	14	14	1.406	SA-312 TP316	550.6	2235	Subcooled liquid	Air (120, 0)
9	RCS	Pressurizer Spray Line	6"-RCS-2501R B,C	6	6.625	0.719	SA-312 TP316	550.6	2235	Subcooled liquid	Air (120, 0)
10	MSS	Main Steam Line	32"-MSS-1532N A,B,C,D	32	32	1.496	SA333 Gr.6	535	907	Saturated steam	Air (130, 0)
11	CVS	Aux. Spray Line	3"-RCS-2501	3	3.5	0.438	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
12	CVS	Aux. Spray Line	3"-CVS-2561	3	3.5	0.438	SA-312 TP316	554.6	2366	Subcooled liquid	Air (120, 0)
13	CVS	Charging Line	4"-CVS-2501	4	4.5	0.531	SA-312 TP316	554.6	2366	Subcooled liquid	Air (120, 0)

14	CVS	Charging Line	4"-CVS-2561	4	4.5	0.531	SA-312 TP316	554.6	2366	Subcooled liquid	Air (120, 0)
15	CVS	Charging Line	4"-CVS-2511 (Inside CV)	4	4.5	0.531	SA-312 TP304	130	2600	Subcooled liquid	Air (120, 0)
16	CVS	Charging Line	4"-CVS-2511 (Outside CV)	4	4.5	0.531	SA-312 TP304	130	2600	Subcooled liquid	Air (105, 0)
17	CVS	Charging Line	3"-CVS-2511	3	3.5	0.438	SA-312 TP304	130	2600	Subcooled liquid	Air (105, 0)
18	CVS	Charging Line	2"-CVS-25B1	2	-	-	-	130	2600	Subcooled liquid	Air (105, 0)
19	RCS	MCP Drain	2"-RCS-2501	2	2.375	0.344	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
20	CVS	Letdown Line	2"-RCS-2501	2	2.375	0.344	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
21	CVS	Letdown Line	3"-RCS-2501	3	3.5	0.438	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
22	CVS	Letdown Line	3"-CVS-2501	3	3.5	0.438	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
23	CVS	Letdown Line	3"-CVS-2561	3	3.5	0.438	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
24	CVS	Letdown Line	3"-CVS-0601	3	3.5	0.216	SA-312 TP304	380	350	Subcooled liquid	Air (120, 0)
25	CVS	Letdown Line	4"-CVS-0601	4	4.5	0.237	SA-312 TP304	380	350	Subcooled liquid	Air (120, 0)
26	CVS	Letdown Line	4"-CVS-06A1	4	-	-	-	200	350	Subcooled liquid	Air (105, 0)
27	SIS	Emergency Letdown Line	2"-RCS-2501	2	2.375	0.344	SA-312 TP316	621	2266	Subcooled liquid	Air (120, 0)
28	SIS	DVI Line	4"-RCS-2501	4	4.5	0.531	SA-312 TP316	554.6	2266	Subcooled liquid	Air (120, 0)
29	SIS	SI Pump Line	4"-RCS-2501	4	4.5	0.531	SA-312 TP316	621	2266	Subcooled liquid	Air (120, 0)
30	SIS	SI Pump Line	4"-SIS-2501	4	4.5	0.531	SA-312 TP316	621	2266	Subcooled liquid	Air (120, 0)
31	RCS	Pressurizer Safety Valve Line	6"-RCS-2501	6	6.625	0.719	SA-312 TP316	657	2266	Saturated steam	Air (120, 0)
31	RCS	Pressurizer Safety Depressurization Valve Line	4"-RCS-2501	4	4.5	0.531	SA-312 TP316	657	2266	Saturated steam	Air (120, 0)
32	RCS	Pressurizer Safety Depressurization Valve Line	6"-RCS-2501	6	6.625	0.719	SA-312 TP316	657	2266	Saturated steam	Air (120, 0)
33	RCS	Pressurizer Safety Depressurization Valve Line	8"-RCS-2501	8	8.625	0.906	SA-312 TP316	657	2266	Saturated steam	Air (120, 0)

34	CVS	Seal Injection Line	1-1/2"-CVS-2501	1-1/2	1.9	0.281	SA-312 TP316	130	2266	Subcooled liquid	Air (120, 0)
35	CVS	Seal Injection Line	1-1/2"-CVS-2511	1-1/2	1.9	0.281	SA-312 TP304	130	2600	Subcooled liquid	Air (105, 0)
36	CVS	Seal Injection Line	1-1/2"-CVS-25B1	1-1/2	-	-	-	130	2600	Subcooled liquid	Air (105, 0)
37	CVS	Seal Injection Line	1"-CVS-2511	1	1.315	0.250	SA-312 TP304	130	2600	Subcooled liquid	Air (105, 0)
38	CVS	Seal Injection Line	2"-CVS-2511	2	2.375	0.344	SA-312 TP304	130	2600	Subcooled liquid	Air (105, 0)
39	CVS	Seal Injection Line	2"-CVS-25B1	2	-	-	-	130	2600	Subcooled liquid	Air (105, 0)
40	SIS	Accumulator Tank Drain Line	2"-SIS-06A1	2	-	-	-	300	700	Subcooled liquid	Air (120, 0)
41	SIS	Accumulator Tank Line	14"-SIS-2511	14	14	1.406	SA-312 TP304	300	2485	Subcooled liquid	Air (120, 0)
42	SIS	Accumulator Tank Line	14"-SIS-0601	14	14	0.500	SA-312 TP304	300	700	Subcooled liquid	Air (120, 0)
43	EFS	Emergency Feedwater Pump Line	3"-FWS-1522	3	3.5	0.300	SA-106 Gr.B	471	1185	Subcooled liquid	Air (130, 0)
44	EFS	Emergency Feedwater Pump Turbine Line	6"-EFS-1532	6	6.625	0.432	SA-106 Gr.B	539	938	Subcooled liquid	Air (130, 0)
45	EFS	Emergency Feedwater Pump Turbine Line	6"-MSS-1532	6	6.625	0.432	SA-106 Gr.B	539	938	Subcooled liquid	Air (130, 0)
46	FWS	Feedwater Line	18"-FWS-1805	18	18	1.375	SA-335 Gr.P22	471	1850	Subcooled liquid	Air (130, 0)
47	FWS	Feedwater Line	6"-FWS-1805	6	6.625	0.562	SA-335 Gr.P22	471	1850	Subcooled liquid	Air (130, 0)
48	FWS	Feedwater Line	16"-FWS-1525	16	16	0.844	SA-335 Gr.P22	471	1185	Subcooled liquid	Air (130, 0)
49	FWS	Feedwater Line	3"-FWS-1802	3	3.5	0.438	SA-106 Gr.B	471	1850	Subcooled liquid	Air (130, 0)
50	MSS	Main Steam Line	32"-MSS-1532	32	32	1.500	SA-333 Gr.6	539	938	Saturated steam	Air (130, 0)
51	MSS	Main Steam Line	6"-MSS-1532	6	6.625	0.432	SA-106 Gr.B	539	938	Saturated steam	Air (130, 0)
52	MSS	Main Steam Drain Line	2"-MSS-1532	2	2.375	0.218	SA-106 Gr.B	539	938	Saturated liquid	Air (130, 0)
53	MSS	Main Steam Drain Line	4"-MSS-1532	4	4.5	0.337	SA-106 Gr.B	539	938	Saturated liquid	Air (130, 0)
54	SGS	SGBD Line	3"-SGS-1532	3	3.5	0.300	SA-106 Gr.B	539	938	Saturated liquid	Air (120, 0)

55	SGS	SGBD Line	4"-SGS-1532 (Inside CV)	4	4.5	0.337	SA-106 Gr.B	539	938	Saturated liquid	Air (120, 0)
56	SGS	SGBD Line	4"-SGS-1532 (Outside CV)	4	4.5	0.337	SA-106 Gr.B	539	938	Saturated liquid	Air (105, 0)
57	SGS	SGBD Line	3/8"-SGS-2521	3/8	-	-	-	539	938	Saturated liquid	Air (120, 0)
58	SGS	SGBD Line	3/8"-SGS-25CA	3/8	-	-	-	539	938	Saturated liquid	Air (105, 0)

break. If the effects of breaks of moderate-energy fluid system piping are more severe than those of high-energy fluid system piping, then the provision of this Subsection 3.6.2.1.2.2 is applied.

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 about 2% of the operational period but qualify as moderate-energy fluid systems for the major operational period.

3.6.2.1.2.1 Moderate-Energy Fluid System Piping in PCCV Penetration Areas

Leakage cracks are not postulated in those portion of the piping from PCCV wall to and including the inboard and outboard isolation valves provided that the PCCV penetration meets the requirements of ASME Code, Section III (Reference 3.6-10), Subarticle NE-1120 and the piping is designed so that the maximum stress range based on the sum of Equations (9) and (10) in Subarticle NC/ND-3653 of the ASME Code, Section III (Reference 3.6-9) does not exceed 0.4 times the sum of the stress limits given in NC/ND-3653.

3.6.2.1.2.2 Moderate-Energy Fluid System Piping in Areas Other than PCCV Penetrations

Leakage cracks are postulated in the following piping systems located adjacent to SSCs important to safety.

- For ASME Code, Section III, Class 1 piping, where the stress range calculated by Eq. (10) in NB-3653 is ~~less~~more than 1.2 S(m)
- For ASME Code, Section III (Reference 3.6-9), Class 2 and 3 and non-safety class piping, at axial locations where calculated stress by the sum of Equations 9 and 10 in NC/ND-3653 exceed 0.4 times the sum of the stress limits given in NC/ND-3653.
- For non-safety class piping, which has not been evaluated to obtain stress information, leakage cracks are postulated at axial locations that produce the most severe environmental effects.

3.6.2.1.3 Types of Break/Cracks Postulated

3.6.2.1.3.1 Circumferential Pipe Breaks

Circumferential breaks are postulated in high-energy fluid system piping and branch runs exceeding a nominal pipe size of 1 inch at locations identified by the criteria in Subsection 3.6.2.1.1.2

No breaks are postulated in piping having a nominal diameter less than 1 inch, including instrument lines that are designed in accordance with RG 1.11 (Reference 3.6-13).

If the maximum stress range exceeds the limits specified in Subsection 3.6.2.1.1.2 and the circumferential stress range is greater than 1.5 times the axial stress range, no circumferential break is postulated; only a longitudinal break (Subsection 3.6.2.1.3.2) is postulated.

expected range of impact energies demonstrate the capability to withstand the impact without rupture. Effects on environment and shutdown logics associated with the failure of the impacted pipe are considered.

3.6.2.5 Placement of essential SSCs in segregated areas, which are not subject to the Implementation of Criteria Dealing with Special Features

Special features such as pipe whip restraints, barriers, and shields are discussed in Subsection 3.6.2.4.4.

3.6.2.6 Outline of Pipe Break Hazard Analysis Report(s)

The following information is outline of methodology for the pipe break hazard analysis that will be completed for all the piping systems (including the non-safety class piping) in accordance with closure of Inspections, Tests, Analyses and Acceptance Criteria (ITAAC) Tier 1, Table 2.3-2 related to pipe break hazard analysis report:

- Identification of pipe break locations in high energy piping[1]
- Identification of leakage crack locations in high and moderate energy piping
- Identification of SSCs that are safety-related or required for safe shutdown[2]
- Evaluation of consequences of pipe whip and jet impingement
- Evaluation of consequences of spray wetting, flooding, environmental conditions
- Design and location of protective barriers, restraints, and enclosures

Notes

1. Table 3.6-2 shows the list of high energy lines for pipe break hazard analysis, including properties of internal and external fluids.

2. All the SSCs that are safety-related or required for safe shutdown in close proximity to the postulated pipe rupture will be identified.

3.6.3 LBB Evaluation Procedures

This subsection describes the design basis to eliminate the dynamic effects of pipe rupture (Subsection 3.6.2) for the selected high-energy piping systems of RCL piping, RCL branch piping, and main steam piping. GDC 4 of Appendix A to 10 CFR 50 (Reference 3.6-1) allows exclusion of dynamic effects associated with pipe rupture from the design basis, when analyses demonstrate that the probability of pipe rupture is extremely low for the applied loading resulting from normal conditions, anticipated transients and a postulated SSE. The LBB evaluation is performed in accordance with SRP 3.6.3 (Reference 3.6-4).

The LBB analysis combines normal and abnormal (including seismic) loads to determine a critical crack size for a postulated pipe break. The critical crack size is compared to the size of a leakage crack for which detection is certain. If the leakage crack size is sufficiently smaller than the critical crack size, the LBB requirements are satisfied.

The piping systems, for which the LBB criterion is not applied, are evaluated for dynamic effects of postulated pipe rupture at locations defined in Subsection 3.6.2. For piping systems for which LBB is demonstrated, the evaluation of environmental effects including spray wetting, and flooding is still performed for breaks or leakage cracks in accordance with Subsection 3.6.2.

The COL Applicant is to identify the types of as-built materials and material specification used for base metal welds, weldments, and safe ends for piping evaluated for LBB. Additionally, the COL Applicant is to provide information related to as-built material and material specifications for piping including toughness (J-R curves) and tensile strength (stress-strain curves), yield and ultimate strength, welding process/methods used, provide confirmation that the actual plant-specific stress analysis based on final as-built plant piping layout and material properties and welds satisfy the bounding LBB analysis, and provide confirmation that the final bounding LBB analysis addresses all plant-specific and generic degradation mechanisms in the as-built piping systems. This issue is to be resolved in ITAAC described in Table 2.3-2 of Tier 1 Chapter 2.3.