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

December 1, 2009

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-09542

Subject: MHI's Responses to US-APWR DCD RAI No. 459-3331

Reference: 1) "Request for Additional Information No. 459-3331 Revision 1, 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 9/16/2009.
2) "MHI's Responses to US-APWR DCD RAI No. 459-3331," UAP-HF-09488, dated 10/19/2009.

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. 459-3331, Revision 1."

Enclosed are the responses to the remaining 9 RAIs contained within Reference 1. Eleven additional RAI responses contained within Reference 1 were previously provided in Reference 2.

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.

Enclosures:

1. Affidavit of Yoshiki Ogata
2. Responses to Request for Additional Information No. 459-3331, Revision 1 (Proprietary)
3. Responses to Request for Additional Information No. 459-3331, Revision 1 (Non-Proprietary)

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

<u>Contact Information</u>
C. Keith Paulson, Senior Technical Manager
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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-09542

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. 459-3331, Revision 1," 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 1st day of December, 2009.

Y. Ogata

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

Enclosure 3

UAP-HF-09542
Docket No. 52-021

Responses to Request for Additional Information No. 459-3331,
Revision 1

December, 2009
(Non-Proprietary)

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-28

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-9(e).

In its response to RAI 03.06.02-9(e), MHI referred to its response to RAI 03.06.02-13. However, the staff found the response of RAI 03.06.02-13 not acceptable. Thus, it does not adequately address the concern of how potential feedback between the jet and nearby reflecting surface(s). The staff requests MHI to address the original RAI item (e). For your convenience, it is updated and restated below.

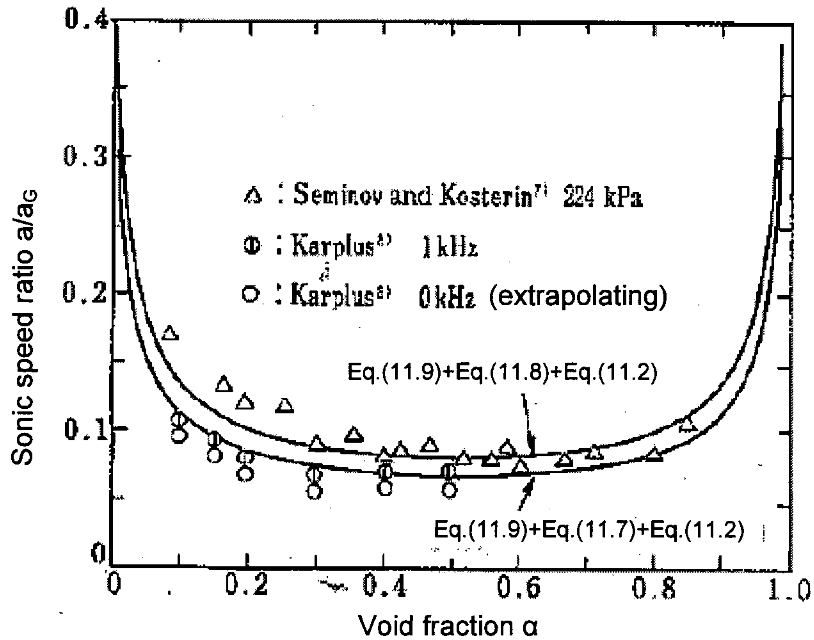
RAI 03.06.02-9(e)
SRP Section 3.6.2, Item III.2.A provides dynamic analysis criteria and discusses material capacity limitations for a crushable material type of whip restraint, while SRP Section 3.6.2, Item III.2.B discusses various methods of analyses. Also, ANSI/ANS-58.2-1988, Section 6.3 presents several different types of dynamic analysis methods. In US-APWR DCD Tier 2 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) – (d) Not shown here.

(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.

ANSWER:

The sonic speed of air-liquid two phase flow is decreased because the sonic wave is reflected by droplets as shown in the figure below. This decrease of sonic speed varies with droplet density, and the sonic speed itself has a distribution in the jet. Then the resonance phenomena itself does not occur because the frequency of pressure wave propagation changes by location. Therefore, the feedback of dynamic blowdown forces does not occur and amplification of feedback of dynamic blowdown forces does not have to be considered for calculating the blowdown forcing functions at break locations.



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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-29

This is the supplemental RAI S01 for RAI 71-986 (questions 10-15 were responded to by MHI Ref: UAP-HF-08258, dated 11/7/2008), 03.06.02-10.

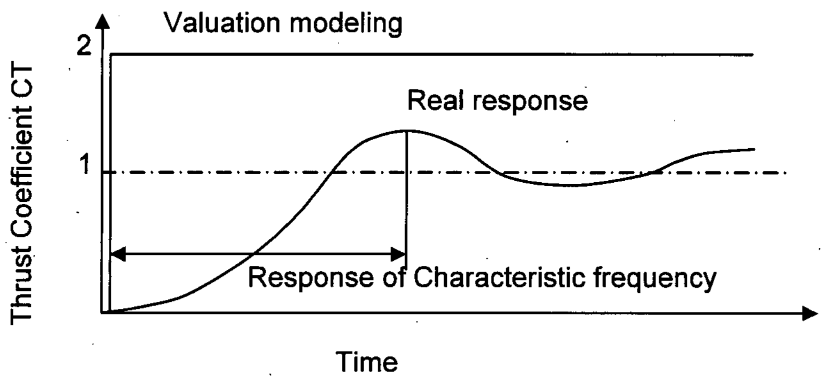
In its response to RAI 03.06.02-10, MHI stated that the loading time duration of a blast wave on a structure neighboring a pipe break would be negligibly small (less than 1/400th of a second), so that the impulse load acting on the structure (computed by integrating the product of the force and application time) would be negligible compared with loads induced by a jet impingement. However, based on the information in the Knowledge Base for Emergency Core Cooling System Recirculation Reliability, February 1996, Issued by the NEA/CSNI, http://www.nea.fr/html/nsd/docs/1995/csnir1995-11.pdf, and ACRS concerns [Wallis - ADAMS ML050830344, Ransom – ADAMS ML 050830341], all high pressure and temperature pipes should be considered as sources of blast waves with initial energy and mass roughly equal to the exposed volume from a hypothesized break. The subsequent damage from such waves has been well documented and is not properly accounted for in ANS 58.2 by the isolated analysis of a pure spherically expanding wave. MHI should provide a rigorous and thorough explanation of their procedures for estimating the effects of blast waves on nearby SSCs. Also, the staff points out that blast wave load analyses should be based on three dimensional (or asymmetric) unsteady analysis of the flow field, with appropriate representation of the surrounding structures, subsequent to the initial blast. MHI is requested to document their blast wave assessment approach(es) in a revised version of the DCD.

ANSWER:

The propagation of shock wave is affected by the surrounding sonic speed. The sonic speed at the end of the propagating shock wave is one of air, because downstream of the shock wave is air. It is possible that the blast wave force is evaluated using the pressure difference between the shock wave back and forward, and the velocity of the shock wave. Also, the property of shock wave can be evaluated using the pressure ratio of pipe break opening mouth to atmosphere and initial energy of pipe break opening mouth.

This progressive velocity of the shock wave seems to be greater than sonic speed of the air and the passing time duration of shock wave on a structure is extremely short. Even if the Mach number of shock wave is equal to 1.0, the passing time duration of shock wave on a barrier structure having thickness of 1 m (3.28 ft) is about 1/350th of a second. Therefore, as for the barrier structure having natural frequency of less than 50Hz, the passing time duration of shock wave on the barrier structure is a split second.

The force on the barrier structure subjected to blast wave is as shown in the figure below. The response of the barrier structure can not follow the shock wave because the shock wave passes the barrier structure in a split second. The force on the barrier structure subjected to blast wave is less than twice of the static force generated by shock wave. Therefore, the MHI method is conservative even if dynamic response is 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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-30

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-11(a).

In its response to RAI 03.06.02-11(a), MHI cited both ANS 58.2 and their own methodologies (some of which were provided in Attachment 1, and were based on measurements cited in references 1-6 in their response to RAI 03.06.02-11). It is not clear exactly which procedures were being applied. MHI provided a similar response to RAI 03.06.02-12(a). The references showed measurements which clearly contradicted the methodologies in ANS 58.2. MHI is therefore requested to clarify which procedures are used for their design calculations. If different procedures are used for different portions of the plant, MHI should clearly state this. MHI is advised that the methodologies in the ANS 58.2 standard, unless proven conservative, are no longer considered universally acceptable for modeling jet forces in nuclear power plants. Alternative analysis approaches are acceptable, provided they are substantiated by valid benchmarks (such as the measurements in the citations). MHI is requested to document any revisions to their jet loading analysis approach in a revised version of the DCD.

ANSWER:

MHI uses the analysis or evaluation method as presented in Attachment 1 (MHI Proprietary). Some portions of ANS 58.2 are cited in the Attachment 1.

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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-31

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-12(a).

In its response to RAI 03.06.02-12(a), MHI cited both ANS 58.2 and their own approach for computing jet loads. Their approach, based on references 1-6 in their response to RAI 03.06.02-11, was described in Attachment 1. It appears that MHI's approach overrided most (if not all) of ANS 58.2. While this may be acceptable (provided the new approach is substantiated by appropriate benchmarks, such as the measurements in MHI's citations), it is unclear what, if any, sections of ANS 58.2 were actually applied. While MHI allowed for varying jet expansion angles (a departure from ANS 58.2), they maintained the assumption that the pressure is uniform over the jet (section 4.3 of Attachment 1 to their RAI response). This assumption was directly contradicted by the measurements presented in their citations. The references cited by MHI in their RAI response (1-6) clearly showed strongly nonuniform pressure distributions which varied with distance from the pipe break. MHI is requested to justify assuming a uniform pressure distribution in light of the existing measurements. Should MHI revise their approach to modeling pressure distributions, the revision should be documented in a revised version of the DCD.

ANSWER:

MHI uses the analysis or evaluation method as presented in Attachment 1. Some of the portion of ANS 58.2 is cited in the Attachment 1.

The pressure essentially has non-uniform distributions which varies with distance from the pipe break as shown in References 1-6 in our response to RAI 03.06.02-11. However, MHI uses maximum pressure in the non-uniform distribution as uniform distribution conservatively.

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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-32

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-12(b).

In its response to RAI 03.06.02-12(b), MHI provided a new table of postulated pipe break locations to which Leak Before Break (LBB) criteria are to be applied. MHI is requested to expand the table to include all postulated pipe breaks, along with the properties of the fluids inside and outside the pipes.

ANSWER:

The following table shows the properties for piping to which LBB will be applied and other high energy piping, including properties of internal and external fluids.

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.

Table for Response to RAI 459-3331, Question 03.06.02-32

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)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-33

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-13.

In its response to RAI 03.06.02-13(a), MHI maintained that the only dynamic portion of jet loading considered was the initial quasi-steady transient as the jet slowly evolved into a steady state phenomenon. To address the initial transient, MHI treated it as a sudden ramp up in loading, and applied the well known Dynamic Load Factor (DLF) of 2.0 to a static analysis of the structural response. MHI ignored the more rapid oscillations that occur within jets, however. These oscillations may occur hundreds (or even thousands) of times in a second. In their response to (b), MHI seemed to acknowledge that these oscillations occur, but discounted any possibility of the oscillations being magnified by the presence of nearby impinged-on structures. MHI's justification for ignoring feedback and resonance was that the fundamental structural resonances of neighboring objects were expected to be well below any jet oscillation frequencies. This justification ignored the feedback and amplification that occurs within a jet even for rigid neighboring structures. Finally, it is clear from MHI's response to (c) that high-frequency dynamic jet loads were not considered in their analyses.

MHI is advised that the ANS 58.2 standard is no longer universally acceptable, unless proven conservative, for modeling jet forces in nuclear power plants, and that dynamic effects beyond those due to the initial transient assumed in ANS 58.2 (0.1 millisecond ramp time) may need to be considered in the DCD. MHI is requested to consider the high-frequency oscillations within jet flows and how they are magnified by the presence of neighboring structures, along with the dynamic response of neighboring structures excited by these oscillations. In references 5 (Masuda, 1983, figures 6 and 9) and 6 (Isozaki, 1986, figure 7) of MHI's response to RAI 03-06-02-11, strong oscillations in the jet pressure fields were clearly visible. The amplitudes of these oscillations were comparable to the static levels. The staff's reference to Ho and Nosseir in the original RAI should also be consulted for evidence of the strong oscillations in jet pressure fields (note that the mean flows in Ho and Nosseir were subsonic, and that oscillatory pressures occurred in supersonic and subsonic jets). MHI is also advised that structural resonances beyond the fundamental are also of interest to the staff, particularly those that resonate at frequencies near the jet loading frequencies. In light of the above, MHI is requested to re-address the original RAI 03.06.02-13 (items a, b, and c). MHI should include any revisions to their jet loading modeling methodology in a revised version of the DCD.

ANSWER:

Refer to the answer for question RAI 03.06.02-28.

Impact on DCD

There is no impact on the COLA.

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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-34

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-14.

In its response to RAI 03.06.02-14, MHI stated that jets will not reflect from neighboring structures, and instead are converted into flow that remains on the surface of the structure impinged upon. However, if there is sufficient momentum, the impinging jet will be expected to separate from a target. To be more precise, although jets do not always separate from impinged-on surfaces and impinge on surrounding structures, it is expected that they generally do so, and reflections may need to be considered. MHI is therefore, requested to provide a conservative approach for assessing the effects of jet reflections. In addition, the approach should be documented in a revised version of the DCD.

ANSWER:

Jets that are reflected by structure change direction and expand with decaying by distance. The effects of jet reflections are assessed considering the changes in direction and expansion with decaying by distance.

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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-35

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-15.

In its response to RAI 03.06.02-15, MHI stated that no feedback between any barrier or shield and the jets can occur since all fundamental natural frequencies of the barriers or shields are less than 50 Hz. MHI did not consider the potential for feedback and resonance within the jet itself, as documented within Ho and Nosseir, and by Powell (JASA, 83 (2), 515-533, February 2008). This feedback and resonance has nothing to do with the oscillations of the neighboring structure (although those oscillations can introduce further amplifications). MHI is advised that the ANS 58.2 standard is no longer universally acceptable, unless proven conservative, for specifying jet loads over barriers, shields, and enclosures in nuclear power plants, and that dynamic effects beyond those due to the initial transient assumed in ANS 58.2 may need to be considered. MHI should consider realistic jet loads which include dynamic effects and possible resonant amplification in their response to this RAI. MHI is advised to consult the Ho and Nossier reference cited in follow-up RAI 03.06.02-13, along with Powell (JASA, 83 (2), 515-533, February 2008) for guidance on the potential for feedback and resonance within a jet itself (irrespective of any structural resonance) prior to responding. MHI is also advised that structural resonances above the fundamental, when strongly excited, can also lead to the destruction of barriers or shields, and is asked again to explain how the barriers and shields will be designed so that they will not be damaged or destroyed by dynamic jet loading. The barrier and shield design approach should be included in a revised version of the DCD.

ANSWER:

Refer to the answer for question RAI 03.06.02-28.

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

12/1/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 459-3331 REVISION 1**
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:	**09/16/2009**

QUESTION NO.: RAI 03.06.02-39

This is the supplemental RAI S01 for RAI 71-986, 03.06.02-18.

In the original RAI 03.06.02-18, MHI was requested to identify a list of information that will be included in the pipe break analysis report along with its (as-design aspect) completion schedule. In its response to the RAI, MHI stated that COL Item in Subsection 3.6.4 is modified in Revision 1 of the DCD. The revised COL Item states that the COL applicant is to implement the criteria for defining break and crack locations and configurations for the site-specific high-energy and moderate-energy piping systems. In addition, the COL applicant is to identify the postulated rupture orientation of each postulated break location for site-specific high-energy and moderate-energy piping systems. Furthermore, the COL applicant is responsible for the as-built reconciliation of these site-specific high-energy and moderate-energy piping systems.

In its RAI response, MHI also referred to UAP-HF-08123 which describes MHI's design completion plan for piping systems and components. Specifically, it states that for ASME Class 1 piping, the dynamic effect evaluation for risk significant piping will be issued in December 2010 and the evaluation for other piping will be issued prior to material procurement. For ASME Class 2 and 3 piping, the dynamic effect evaluation for main steam piping will be issued in December 2010, the evaluation for risk significant piping will be issued in June 2012, and the evaluation for other piping will be issued prior to material procurement. Based on its review of the above information, the staff found that MHI did not address the original RAI adequately.

MHI should note that there are three areas involved in the pipe break analysis. These three areas are the methodology or the criteria for evaluating the effects of postulated pipe failures, the design aspect of the pipe break analysis report performed in according to the methodology, and then the as-built reconciliation to ensure the plant is built in according to the design and meets the applicable regulation. Since MHI indicates that the design aspect of the pipe break analysis will be performed by MHI and the COL applicant (for the site-specific piping), MHI should include a description in DCD Tier 2 Section 3.6.2 that clearly outlines the information that will be included in the as-designed pipe break analysis report. This is to ensure that the design aspect of the pipe break analysis report will contain sufficient information for the staff's review to ensure that the design is performed in according to the DCD methodology and meets the applicable regulation.

In addition, the staff noted that MHI includes only ASME Class 1, 2, and 3 piping but not non-safety class piping that is within the scope of SRP 3.6.2. Furthermore, MHI did not adequately address the closure milestone of the as-designed pipe break analysis report for all the piping systems that are within the scope of SRP 3.6.2. The DCD should include a description to address the point that the process will allow the coordination with staff's review, such that it will make the final as-designed pipe break analysis report available for NRC review. It should be noted that if the final as-designed pipe break analysis will not be completed within the design certification review phase, MHI is requested to propose an ITAAC to address the as-designed (in addition to the as-built) pipe break analysis including a description pertaining to the closure schedule of the report or an acceptable alternative. MHI is requested to address the above concerns.

ANSWER:

The outline of the as-designed pipe break analysis report will be included in Revision 3 of DCD Tier 2, Section 3.6.2.

Design ITAAC for as-designed pipe break analysis report will be included in Revision 3 of DCD Tier 1, Section 2.3.

Impact on DCD

See Attachment 2 for a mark-up of DCD Tier 2, Section 3.6 changes to be incorporated.

- Add the following Subsection 3.6.2.6:

  "**3.6.2.6 Pipe Break Hazard Analysis Methodology**

  The following information is the outline of the methodology for the pipe break hazard analysis that will be completed in accordance with closure of ITAAC described in Table 2.3-2 of Tier 1 Chapter 2.3, relating to the pipe break hazard analysis report:

  - Identification of pipe break locations in high energy piping
  - Identification of leakage crack locations in high and moderate energy piping
  - Identification of SSCs that are safety-related or required for safe shutdown
  - 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"

See Attachment 3 for a mark-up of DCD Tier 1, Section 2.3 changes to be incorporated.

- Change the description for Design Commitment, Inspections, Tests, Analyses, and Acceptance Criteria for item 4 in Table 2.3-2
- Add item 5 description for Design Commitment, Inspections, Tests, Analyses, and Acceptance Criteria for in Table 2.3-2.

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.

Proprietary

ATTACHMENT 1
to RAI 459-3331

Attachment 1

Evaluation Method on Jet Expansion and Impingement

(Non-Proprietary Version)

[Important Notice]

This document contains proprietary information of Mitsubishi Heavy Industries, LTD ("MHI"). MHI requests that the NRC withhold this information from public disclosure. This first page of the document indicates that all information is identified as "Proprietary" and should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

ATTACHMENT 2
to RAI 459-3331

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 Pipe Break Hazard Analysis Methodology

The following information is the outline of methodology for the pipe break hazard analysis that will be completed in accordance with the closure of ITAAC described in Table 2.3-2 of Tier 1 Chapter 2.3, relating to the pipe break hazard analysis report:

- Identification of pipe break locations in high energy piping
- Identification of leakage crack locations in high and moderate energy piping
- Identification of SSCs that are safety-related or required for safe shutdown
- 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

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.

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 ~~have adequate high-energy pipe break mitigation features.~~ are protected against or qualified to withstand the dynamic and environmental effects associated with analyses of postulated failures in high-energy piping and moderate-energy piping systems.	4.i ~~A pipe break analysis of the as-built high-energy line will be performed.~~ 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 ~~The reconciliation of the as-built configuration of high-energy pipe lines concludes that,~~ Report(s) 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. ~~For postulated pipe breaks,~~ ~~t~~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~~ and (D) SSCs are protected or qualified to withstand the environmental effects of postulated failures~~.
	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, environmental conditions, as appropriate.	4.ii Report(s) 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 as-designed high-energy pipe break mitigation features.	5. A reconciliation analysis of the as-built high-energy piping using as-designed pipe break hazard analysis report and as-built information will be performed.	5. Report(s) exist and conclude that the high-energy pipe break mitigation features are installed in the as-built plant as described in the design and reconciliation analysis.