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

September 19, 2012

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-12230

Subject: Amended MHI's Response to US-APWR DCD RAI No. 804-5938 Revision 3 (SRP 03.12)

References: 1) "Request for Additional Information No. 804-5938 Revision 3, SRP Section: 03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports," dated August 11, 2011.
2) "MHI's Response to US-APWR DCD RAI No. 804-5938 Revision 3 (SRP 03.12)," UAP-HF-11382, dated November 10, 2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Amended Response to Request for Additional Information No. 804-5938 Revision 3."

Enclosed is the response to Question 03.12-26 of the RAI804-5938 contained within Reference 1. This response amends the previously transmitted response submitted under MHI's Letter UAP-HF-11382 dated November 10, 2011 (Reference 2) in order to incorporate comments from the NRC staff into the response.

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 Mr. Joseph Tapia, General Manager of Licensing Department, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

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NRO

Sincerely,

Y. Ogata

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

Enclosure:

1. Affidavit of Yoshiki Ogata
2. Amended Response to Request for Additional Information No.804-5938 Revision 3 (Proprietary)
3. Amended Response to Request for Additional Information No.804-5938 Revision 3 (Non-Proprietary)

CC: J. A. Ciocco
J. Tapia

Contact Information
Joseph Tapia, General Manager of Licensing Department
Mitsubishi Nuclear Energy Systems, Inc.
1001 19th Street North, Suite 710
Arlington, VA 22209
E-mail: joseph_tapia@mnes-us.com
Telephone: (703) 908 – 8055

Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF- 12230

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am Director, 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 "Amended Response to Request for Additional Information No. 804-5938 Revision 3," and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those 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 US-APWR.

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 of modeling and analysis.

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 19th day of September, 2012.

Y. Ogata

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

Enclosure 3

UAP-HF-12230
Docket No. 52-021

Amended Response to Request for Additional Information
No.804-5938 Revision 3

September, 2012
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/19/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 804-5938 REVISION 3**

SRP SECTION: **03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**

APPLICATION SECTION: 03.12

DATE OF RAI ISSUE: 08/11/2011

QUESTION NO.: RAI 03.12-26

DCD Tier 2, Section 3.12.3.4 states that seismic analysis of piping system is not performed using the time-history method. However, DCD Tier 2, Appendix 3C and section 3.9.3.1.4 states that RCL piping dynamic analysis is performed using time-history direct integration, the time-history modal, or response spectra methods. The staff is requesting MHI to clarify the difference by revising Section 3.12.3.4.

DCD Tier 2, Figure 3.8.3-2 showed SG lower support structure drawing. Two supports (parallel to hot leg) of SG lower lateral support structure functioned as non-linear one-direction supports. In general, non-linear dynamic analysis is analyzed using time-history direct integration method. The response spectra method or time-history modal is used in linear elastic dynamic analysis. The staff is requesting MHI to provide basis for using time-history modal, or response spectra methods for the non-linear support system. The staff also requests MHI to clarify which method is used for the RCL piping analysis and put the correct method in the DCD.

In RAI 03.12-16 response, MHI stated that SG lower lateral support will be installed to not restrain thermal expansion. The gap between SG and SG lower lateral support will be adjusted so that support will come in contact with SG only during operating condition. Figure 3.8.3-2 (Sheet 3 of 4) does not provide sufficient detail, the staff is requesting MHI to provide lower lateral support structure information and geometrical thermal calculation to ensure that there is enough clearance between the two supports closer to hot leg and SG during cooldown.

ANSWER:

DCD Tier 2, Subsection 3.12.3.4, applies to piping other than reactor coolant loop (RCL) piping, as describes in Subsection 3.12.1 which states: "The design of the RCL piping is covered by Subsection 3.9.3" Thus, there is no inconsistency to state in Subsection 3.9.3.1.1 that RCL piping dynamic analysis is performed using time-history direct integration, the time-history modal, or response spectra methods.

The seismic and accident design analysis method for the US-APWR Reactor Coolant Loop (RCL) system components is presented in MUAP-09002-P Rev.2, "Summary of Seismic and Accident Load Conditions for Primary Components and Piping". The seismic design of the primary components and piping system are based on the decoupled RCL analysis model, as presented in Section 5.2 of MUAP-09002-P Rev.2.

The reason for using decoupled RCL analysis is the seismic design of R/B complex has changed to be based on a set of SSI analyses using SASSI, and considering generic profiles of layered ground subgrade properties on DCD Rev.3.

The following issues related to RCL seismic analysis appeared.

- SASSI was originally developed for structural analysis of civil design. It is not always suitable for the analysis of mechanical components of RCL structure, such as pipe elbow, special beam with pin connection, spring element which represents the nozzle stiffness, rigid connection, etc.
- It is necessary to account for uncertainties in the structural frequencies owing to uncertainties in the material properties of the equipments, R/B, and soil and to approximations in the RCL modeling procedures. Therefore, for the response spectrum analysis, it is regulated to broaden ±15 % design response spectrum as stated in RG 1.122, and for time-history response analysis, it is recommended to use at least three different scaled time intervals as stated in ASME Section III Appendix N. Because it is required to broaden procedures as above for each soil condition, much calculation time and cost are needed for coupled RCL - R/B model.

Therefore, it is better to practically apply the decoupled RCL analysis method, considering the multiple support excitations. Two methods are selected, one is the independent support motion method (ISM), and the other is time history analysis method with direct integration.

The former method is thought to be most suitable for standard design for the RCL components and piping, because it is relatively straightforward for the safety side design to apply the enveloped spectra with ±15% broadened, corresponding to cover the generic layered profiles with wide variation of soil properties.

For the support design, such as the SG lower lateral support, the time history analysis method, considering both effects of non-linear one-direction supports with small gap and the building frequency shift of ±15 % will be selected. Gaps shall be controlled to be less than [ ] inch. As a consequence of the hot functional test, as presented in Figure 1. The non-linear support model is presented in Figure 2.

Finally, MHI will justify the design validity of ISM method of RCL seismic design by comparison with non-linear time history analysis of one-direction support model. With the change of the analysis method, DCD descriptions are changed as "Impact on DCD".

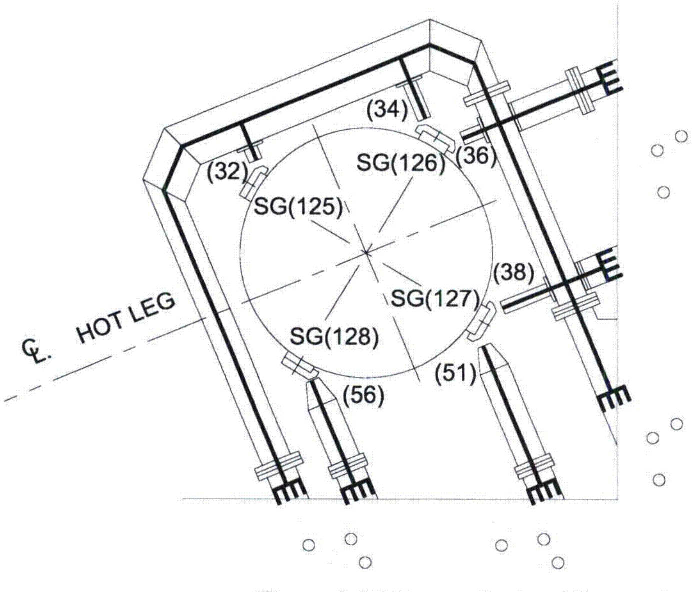
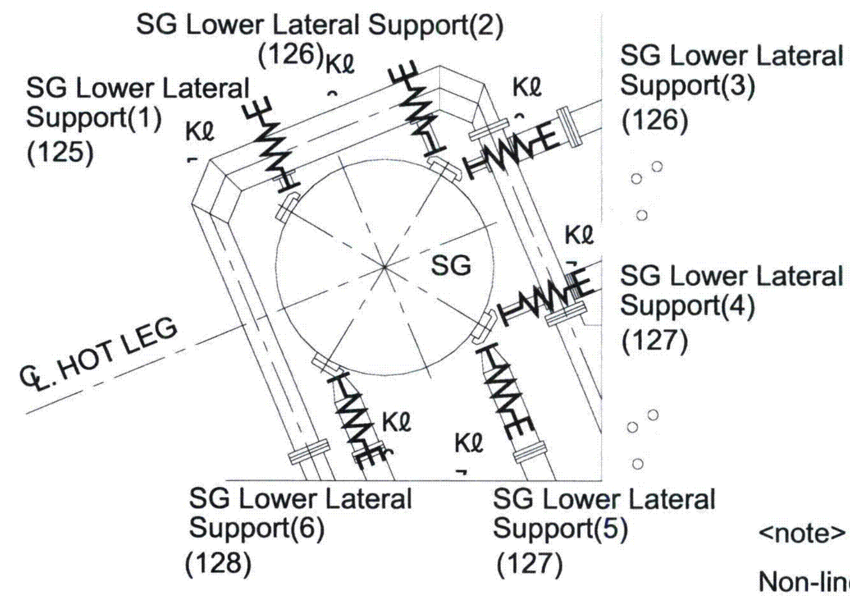


Figure1 SG Lower Lateral Support

<note>

Gaps between SG lower shell and the lateral support shall be controlled to be less than [ ] inch, after the hot functional test.



<note>

Non-linear properties are considered in the time history analysis with direct integration.

Figure 2 Non-Linear Support Model

Impact on DCD

There are some modifications and changes about RCL modeling method and analysis method as following reasons. DCD Tier 2, Section 3.7.3.1.7, 3C.1, 3C.5, 3C.6 and 3C.7 will be revised as shown in Attachment 1.

- Modify the sentence that have described analysis method and modeling for RCL.

  Section 3.7.3.1.7: delete the second paragraph

  Appendix 3C.1, second paragraph: replace the first sentence of the second paragraph to "RCL dynamic analysis is applied for the decoupled model from reactor building (R/B), prestressed concrete containment vessel (PCCV), and containment internal structure (CIS).

  Appendix 3C.1, third paragraph: replace the first and second sentences of the third paragraph to "The dynamic analysis of the coupled model between building structure and RCL is performed using methods described in Subsection 3.7.2. RCL seismic analysis is performed, using independent support motion method or time-history direct integration analysis method, described in Subsection 3.7.3."

- Change the description that have described the detailed analysis method for the RCL analyses

  Appendix 3C.5: replace the whole sentences to describe about decoupled RCL analysis method, to consistent with the technical report MUAP-09002-P Rev.2. Detailed shown in Attachment 1.

- Refer the technical report MUAP-09002 Rev.2

  Appendix 3C.7: add the reference document "Summary of Seismic and Accident Load Conditions for Primary Components and Piping, MUAP-09002, Rev. 2 (Proprietary) and MUAP-09002, Rev.2 (Non-Proprietary), December 2010" as 3C-2 after current 3C-1.

- Other editorial changes

  Appendix 3C.1, fourth paragraph: replace the first sentence from "RCL structural analysis" to "RCL accident analysis"

  Appendix 3C.6, second sentence: change "(Reference 3C-2)" to "(Reference 3C-3)"

  Appendix 3C.6, third sentence: change "Refer to Subsection 3.7.2.3" to "Refer to Subsection 3.7.2.3 and 3.7.3"

  Appendix 3C.7, 3C-2: change current "3C-2" to "3C-3", and change the release number of ANSYS Code from "Release 11.0" to "Release 12.1". Also change the published year from 2007 to 2010.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

3.7.3.1.6 Seismic Response Spectra Peak Shifting

The peak shifting method may be used in place of the broadened spectra method. It determines the natural frequencies $(f_e)_n$ of the system to be qualified in the broadened range of the maximum spectra acceleration peak. If no equipment or piping system natural frequencies exists in the ±15% interval associated with the maximum spectra acceleration peak, then the interval associated with the next highest spectra acceleration peak is selected and used in the following procedure.

Consider all *N* natural frequencies in the interval:

$$f_j - 0.15f_j \leq (f_e)_n \leq f_j + 0.15f_j$$

where

f_j = the frequency of maximum acceleration in the envelope spectra

n = 1 to *N*

The system is evaluated by performing *N*+3 separate analyses using the envelope un-broadened ISRS and the envelope un-broadened spectra modified by shifting the frequencies associated with each of the spectral values by a factor of +0.15; -0.15; and

$$\frac{(f_e)_n - f_j}{f_j}$$

where

n = 1 to *N*

The results of these separate seismic analyses are then enveloped to obtain the final result desired (e.g., stress, support loads, acceleration) at any given point in the system. If three different ISRS curves are used to define the response in the two horizontal and the vertical directions, then the shifting of the spectral values, as defined above, may be applied independently to these three response spectra curves.

3.7.3.1.7 Multiple Support Response Spectra Input Methods

The uniform support motion method and the independent support motion methods use multiple-input response spectra which account for the phasing and interdependence characteristics of the various support points. These methods are based on the guidelines provided by the "Pressure Vessel Research Committee Technical Committee on Piping Systems" (Reference 3.7-38) and have been most often applied to plant piping subsystems but are also applicable to other subsystems with multiple support points.

~~For select equipment (e.g., RCS components), the time history approach using a coupled model with supported structures is applied.~~ DCD_03.12-26 S01

Attachment 1 to RAI 804-5938

3C Reactor Coolant Loop Analysis Methods

3C.1 Introduction

This Appendix provides the analytical methods of the reactor coolant loop (RCL) piping and support system model.

~~The RCL dynamic analysis may be applied for the coupled model that is combined with the RCL,~~RCL dynamic analysis is applied for the decoupled model from reactor building (R/B), prestressed concrete containment vessel (PCCV), and containment internal structure (CIS). The RCL properties of the model are based on this Appendix. DCD_03.12-26 S01 DCD_03.12-26 S01

The dynamic analysis of the coupled model between building structure and RCL is performed using methods described in Subsection 3.7.2. ~~The RCL dynamic analysis is performed using time history direct integration, the time history modal, or response spectra methods.~~RCL seismic analysis is performed, using independent support motion method or time-history direct integration analysis method, described in Subsection 3.7.3. The resulting static and dynamic loads generated from the RCL piping and the component support models provide the end loads and displacements at the connecting components and support points for each loop analyzed.

RCL ~~structural~~accident analysis is performed for the postulated pipe rupture cases considering the applicable leak-before-break criteria. Analysis methods apply time history direct integration or equivalent static analysis. External loads of pipe rupture, thrust loads, jet impingement loads, and subcompartment pressure loads are appropriately considered. The enveloping load is conservatively applied as the design load of the component. The combination of loads for Class 1 components and supports is discussed in Design Control Document (DCD) Subsection 3.9.3.1.3. Refer also to DCD Subsection 3.9.3.1 for additional discussion on the modeling of the RCL piping and support system. DCD_03.12-26 S01

3C.2 RCL Model Description

The analysis model consists of the RCL hot, cold, and cross-over loop piping, steam generator (SG), reactor coolant pump (RCP), reactor vessel (RV), and component supports, as applicable, for each loop. The RCL piping and support system is modeled as three-dimensional finite elements (FEs) representing the components, pipes, and supports as beam elements, masses, and springs with imposed boundary conditions. The RCL of the US–APWR has four loops, which are modeled as beginning and ending at the hot leg and cold leg RV nozzles. These combined system models include both the translational and rotational stiffness, mass characteristics of the RCL piping and components, and the stiffness of supports. The stiffnesses and mass effects of auxiliary line piping are considered when they affect the system.

3C.2.1 Modeling of Primary Components and Equipment

The SG, RCP, and RV are modeled using equivalent pipe and beam elements, and are represented by lumped masses in each loop analysis. The geometry of the component is used to determine the properties of the equivalent piping or beam elements connecting masses. Other properties applied to the equivalent piping or beam elements include the

Attachment 1 to RAI 804-5938

3C.4.1 Deadweight

The RCL is statically analyzed for the total weight of the RCL piping, equipment, and ancillary items including the weight of water. Deadweight piping mass is distributed by lumped mass during static analyses.

3C.4.2 Internal Pressure

The design value of normal internal operating pressure is utilized for static analyses of RCL pipe stresses and to obtain system support reactions.

3C.4.3 Thermal Expansion

The thermal expansion of the RCL piping, RV, SG, RCP, and the component supports are modeled and analyzed, as applicable. The contributions of the stiffness of auxiliary lines on the RCL piping model are generally negligible, by design of the auxiliary line supports.

3C.5 Dynamic Analyses

~~The RCL piping model for dynamic analyses is developed to include refined mass characteristics of the piping and equipment. The mass and the stiffness characteristics of the equipment are modeled to determine the effect of the equipment motion on the RCL piping model.~~ DCD_03.12-26 S01

~~The RCL piping and support system analysis will be performed for the dynamic effects of an SSE. A coupled model of the containment internal structure and the RCL is used for the dynamic evaluation. The seismic input is obtained from the soil structure interaction model of the RCL, R/B, PCCV, and containment internal structure, and subgrade profiles described in Subsection 3.7.1. The duration of input is between 12 to 20 seconds, depending on the duration necessary to envelope the design response spectra.~~

~~The mass and stiffness characteristics of equipment are modeled to determine the effect of the equipment motion on the RCL piping and support system. The RCL piping model contains lumped masses for the analysis.~~

~~Damping is used with the building components at 5% and the loop components at 3 % of the critical damping.~~The seismic and accident design analysis method for the RCL system components is presented in MUAP-09002 Rev.2, "Summary of Seismic and Accident Load Conditions of Primary Components and Piping" (Reference 3C-2). The seismic design of the primary components and piping system are based on the decoupled RCL analysis model, as presented in Section 5.2 of MUAP-09002 Rev.2.

The seismic input is obtained from the coupled model of the RCL, R/B, PCCV, and CIS, considering the dynamic effects of an SSE. The effects of soil-structure interaction is also considered for the subgrade profiles described in Subsection 3.7.1.

RCL seismic analysis is performed for using decoupled RCL model analysis, considering the multiple support excitations. The seismic analysis of the decoupled RCL model utilizes the independent support motion (ISM) method and time history analysis method with direct integration.

ISM method is applied for the RCL components and piping design, using the envelop broadened response spectra, corresponding to cover the generic layered profiles with wide variation of soil properties. Time history analysis method is applied for some specific component design, such as the SG lower lateral support, considering both non-linear effect of the support and the building frequency shift. Damping is used for RCL components at 3 % of the critical damping. DCD_03.12-26 S01

RCL accident analysis is based on the time history analysis method, considering the non-linear effects of the SG Lower lateral support, as described above.

3C.6 Description of Computer Programs

Computer programs used for the US-APWR, RCL analysis are consistent with those identified in Sections 3.9 and 3.12. The primary method of analysis for the RCL piping and support system is the FE analysis program ANSYS (Reference 3C-~~2~~3). Refer to Subsection 3.7.2.3 and 3.7.3 for a discussion of the modeling procedures and guidelines. DCD_03.12-26 S01

3C.7 References

3C-1 ASME Boiler and Pressure Vessel Code, Section III. American Society of Mechanical Engineers, 1992 Edition including 1992 Addenda, Subsection NB, NC, and ND.

3C-2 Summary of Seismic and Accident Load Conditions for Primary Components and Piping, MUAP-09002, Rev. 2 (Proprietary) and MUAP-09002, Rev. 2 (Non-Proprietary), December 2010. DCD_03.12-26 S01

3C-~~2~~3 ANSYS, Advanced Analysis Techniques Guide, Release ~~11.0~~12.1, ANSYS, Inc., ~~2007~~2010.