MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

February 14, 2008

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

Attention: Mr. Jeffrey A. Ciocco

Project No.0751
MHI Ref: UAP-HF-08036

Subject: Response to the Request for Additional Information on US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test plan

With this letter, Mitsubishi Heavy Industries, LTD. (MHI) transmits to the U.S. Nuclear Regulatory Commission (NRC) the document entitled "Response to the Request for Additional Information on US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test Plan". In the enclosed document, MHI provides responses to NRC's "REQUEST FOR ADDITIONAL INFORMATION ON THE US-APWR REACTOR VESSEL LOWER PLENUM 1/7 SCALE MODEL FLOW TEST PLAN" dated January 15, 2008.

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) and 10 C.F.R § 9.17 (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 in this package (Enclosure 3). In the non-proprietary version, the proprietary information, bracketed in the proprietary version, is replaced by the designation "[ ]".

This letter includes a copy of the proprietary version (Enclosure 2), a copy of non-proprietary version (Enclosure 3), and the Affidavit of Masahiko Kaneda (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) and 10 C.F.R.§ 9.17(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 the submittals. His contact information is below.

Sincerely,

M. Kaneda

Masahiko Kaneda,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

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NRO

Enclosures:
Enclosure1 - Affidavit of Masahiko Kaneda (non-proprietary)
Enclosure2 - Response to the Request for Additional Information on US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test Plan (proprietary)
Enclosure3 - Response to the Request for Additional Information on US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test Plan (non-proprietary)

CC: L J. Burkhart
J. W. Chung
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ENCLOSURE 1

Project No. 0751

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Masahiko Kaneda, 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) and 10 C.F.R.§ 9.17(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 "Response to the Request for Additional Information on US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test Plan", and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those pages containing proprietary information are 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 document 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 MNH's unique methodology for performing safety evaluations and tests, developed by MHI and not used in the exact form by any of MHI's competitors. This information was developed at significant cost to MHI, since it required the performance of research and development and detailed design of applicable software and hardware extending over several years.

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 development of methodology and tools to verify 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 development of the safety evaluation and testing methodology. Providing public access to such information permits competitors to duplicate or mimic the methodology without incurring the associated costs.

B. Loss of the competitive advantage of the US-APWR created through development of the referenced methodology.

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 14th day of February, 2008.

M. Kaneda

Masahiko Kaneda,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure 3

UAP-HF-08036, Rev.0

Response to the Request for Additional Information

on

US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test Plan

February 2008
(Non-Proprietary)

Response to the Request for Additional Information on US-APWR Vessel Lower Plenum 1/7 Scale Model Flow Test plan (UAP-HF-07080-P rev.0)

Non-Proprietary Version

1. The scale model tests would be conducted in an inverted condition. Provide justification to show that the gravitational and other orientation effects would have negligible influence on the test results or that these effects would be accounted for and the test results would be adjusted accordingly.

(Answer 1)

In general, gravity effects on the fluid flow are limited in the case of free surface or non-uniform mass density distribution. In all cases of US-APWR lower plenum testing, there is no fluid free surface in the test vessel and the inlet pipes. As for the hydraulic test and the flow-induced vibration test, fluid mass density is uniform. Therefore, even in the inverted condition, there is no effect by gravity on the flow conditions in the hydraulic test and the flow induced vibration test.

In the temperature distribution test, the non-uniform mass density condition is generated to simulate the event with overcooling.
The fluid temperature in the event loop will be lower than the other three loops in the actual plant, thus, the direction of buoyancy on the overcooling fluid is downward. This is same with the down comer flow direction.
In the test, the hot water is injected to the event inlet pipe to minimize the hot water tank volume. Hence, the direction of the buoyancy on the injected hot water is upward, which coincides with the down-comer flow direction. Therefore, the inverted condition is qualitatively better for the simulation of the buoyancy effects. Further discussion with non-dimensional parameter Ri will be discussed in the answer to the question 2.

2. The tests would be conducted at room temperature on a 1/7 scale model. The results of a non dimensional analysis to show that tests under these conditions accurately simulate the flow induced vibrations are summarized in Table 4-3. Provide the basis for the selection of the non dimensional parameters and discuss how these are sufficient to accurately simulate the flow induced vibration responses.

(Answer 2)

The Reynolds number Re for the hydraulic test and the reduced velocity Ur for the flow-induced vibration test are selected as the key non-dimensional parameters. In addition for the temperature distribution test, Richardson number Ri is evaluated to check the buoyancy effects on the temperature mixing. Definitions and bases of these non-dimensional parameters are summarized in Table1 and discussed below.

a. Hydraulic test

Re (=UD/ν) based on flow path dimension ,as described in Ref.(1), is a measure to check if the simulation of the turbulent flow condition is maintained. Because the transition from the laminar flow to the turbulent flow occurs at Re of order of 10^3, we have set the criteria at 10^4. This requirement is needed not only for the hydraulic test, but also for the flow induced vibration test and for temperature distribution test.
At nominal conditions for the hydraulic test, Re at the down-comer is $2x10^5$. It remains of order of 10^5 even in minimum flow conditions. These values are sufficiently high to simulate the full developed turbulent flow conditions as in actual plant.

b. Flow-induced vibration test

The reduced velocity Ur (= U/fn D) is generally utilized in the dimension analysis of flow induced vibration . Ur represents the ratio of the path length per cycle (U/fn) and the model width D as described in Ref.(2). From another view, Ur represents the ratio of the fluid force frequency (proportional to U/D, the vortex shedding frequency fs is a typical example) and the model natural frequency. The nominal flow rate in the test should be determined as Ur coincides with that of the plant. If the test model is precisely scaled downed, "fn D" is maintained. Therefore, same velocity is the answer for coincidence of Ur with the plant condition.

The effects of temperature condition on flow induced responses are considered from the view point of flow induced forcing function and stiffness of structure. The main source of flow induced vibration is the turbulence pressure fluctuation and second is vortex shedding. The amplitude of these forcing functions are in proportion with the dynamic pressure($=1/2\rho U^2$), thus, the temperature effect on the flow induced forces can be related to the change of fluid mass density. As for the effect on the structure stiffness, it can be estimated from the ratio of Young's modulus of the material. Therefore, the effect of temperature on vibration response will be corrected with the difference of fluid mass density and the difference of Young's modulus. Total correction factors including scale effects are summarized in Table 2.

c. Temperature distribution test

As discussed in answer 1, the buoyancy effects on temperature mixing is checked by applying the Richardson number Ri. Ri is a non-dimensional parameter which represents the ratio of buoyancy and fluid inertia forces as described in Ref.(3). In both actual plant event conditions and in test conditions, Ri are much smaller than 1.0. This means that the buoyancy effects on temperature mixing is negligibly small, and temperature mixing can be simulated in the test conditions.

3. MNES is requested to provide the number and length of test runs that will be performed for each of the three tests. In addition, MNES is requested to submit the test results to the NRC staff.

(Answer 3)

The number of test runs and measurement time duration for the hydraulic test, FIV test, and the temperature distribution test are shown in Table 3.
The test report will be submitted to NRC by the end of June 2008.

Table 1 Non-dimensional Parameters

	Definition	Bases	Test Requirement	Actual Plant (Approx.)	Test Condition (Approx.)
Hydraulic Test	$Re=UD_1/\nu$	Ratio of fluid Inertia force and viscous force	$Re >> 10^4$ (for developed turbulent flow)		
FIV Test	$Ur = U / fn\ D_2$	Ratio of "path per cycle" and "model width"	Equivalent with plant condition		
Temp. Distribution test	$Ri= gD_1(\delta\rho)/ \rho V^2$	Ratio of buoyancy and fluid inertia force	Equivalent with plant condition or $Ri<<1.0$ for test and plant		

U : flow velocity (=down-comer average velocity)
D_1 : typical length of the flow path (=down-comer width)
D_2 : typical length of the structure(= diameter of diffuser plate support column)
ν : kinematic viscosity
fn : natural frequency
g : gravity acceleration
ρ : fluid mass density
$\delta\rho$: difference of mass density between cold fluid and hot fluid

Table 2　Correction Factors for FIV Test Results (Approx.)

	Effect of Temperature		Scale Factor (1/7 Scale)	Total Correction Factor
	Correction for Fluid Mass Density	Correction for Young's Modulus		
Hydraulic Force	0.75	NA	49	37
Stress	0.75	NA	1/1	0.75
Natural Frequency	1.01	0.95	1/7	0.14
Displacement	0.75	1.1	7	5.8
Acceleration	0.77	NA	1/7	0.11

Table 3　Number of Test Runs and Duration

	ID	Structures in Lower Plenum	LCSP(*1) Flow Hole Orifice	Loop Flow Rate	Number of Test Runs (*2)	Test Duration (per Run)
Hydraulic Test	H1					
	H2					
	H3					
FIV Test	F1					
	F2					
	F3					
	F4					
	F5					
Temp Distribution Test	T1					

*1 : LCSP = Lower Core Support Plate
*2 : + means additional run to check the repeatability

References

(1) Robert D.Blevins, "APPLIED FLUID DYNAMICS HANDBOOK" , 4.4 REINOLDS NUMBER (p10) , VAN OSTRAND REINHOLD COMPANY,1984, ISBN:0-442-21296-8

(2) Robert D.Blevins, "flow-induced vibration" , 2.2.2 Reduced Velocity,Nondimensional Amplitude (p6) , VAN OSTRAND REINHOLD COMPANY,1977, ISBN:0-442-20828-6

(3) J.S. TURNER, "BUOYANCY EFFECTS IN FLUIDS" , p291,CAMBRIDGE AT THE UNIVERSITY PRESS,1973