**MITSUBISHI HEAVY INDUSTRIES, LTD.**
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TOKYO, JAPAN

June 11, 2009

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

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09308

**Subject: MHI's Responses to US-APWR DCD RAI No.366-2740 Revision 1**

**Reference:** 1) "REQUEST FOR ADDITIONAL INFORMATION 366-2740 REVISION 1, SRP Section: 06.02.02 – Containment Heat Removal System Application Section: 6.2.2, QUESTIONS for Component Integrity, Performance, and Testing Branch 1(AP1000/EPR Projects) (CIB1)" dated May 14, 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.366-2740 Revision 1."

Enclosed is the responses to Questions 06.02.02-45 through 06.02.02-51 that are contained within Reference 1.

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,

Y. Ogata

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

Enclosure:

1. Responses to Request for Additional Information No.366 Revision 0

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

D081
NRO

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Enclosure 1

UAP-HF-09308
Docket No. 52-021

# Responses to Request for Additional Information No.366-2740
Revision 0

June 2009

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/11/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

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| **RAI NO.:** | **NO. 366-2740 REVISION 1** |
| **SRP SECTION:** | **06.02.02 – CONTAINMENT HEAT REMOVAL SYSTEM** |
| **APPLICATION SECTION:** | **6.2.2** |
| **DATE OF RAI ISSUE:** | **5/14/2009** |

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**QUESTION NO.: 06.02.02-45**

The MUAP-08013-P report provides the downstream path debris load. The assumed post-LOCA fluid constituents are based on 100% latent debris bypass, 50% fiber bypass, and 5% reflective metal insulation (RMI) bypass, which the report states is more conservative than that assumed for the in-vessel evaluation. Provide the basis for the assumed constituents and amounts. Also, the constituents are assumed to have a characteristic size, but it is expected that the constituents will have a size distribution over a range that includes the smallest size up to the largest size that can pass through the strainer openings. Provide the basis for the assumed characteristic sizes for the debris constituents.

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**ANSWER:**

For plugging evaluations, the maximum size of a debris particle is the limiting parameter. The size distribution is not a concern. Evaluations were performed assuming a larger particle size 110% of the screen opening. This is consistent with USNRC guidance.

For erosive wear, the larger the particle, the greater the potential wear. The rate of erosive or abrasive wear in piping is proportional to the velocity and quantity of flow and size and shape of the particle in solution. The erosive wear calculations conservatively assume that all particles are large particles. This assumption maximizes the wear potential. The assumption of a particle size distribution would lower the wear potential and is not conservative.

It was assumed that 100% of the latent debris reaches the sump strainer and that all particles smaller than 110% of the screen opening size pass through. No credit is assumed for settling or capture by the sump screen. This is conservative in that some latent debris may not transport, some debris may settle due to low velocities in the RWSP and in the reactor vessel, some debris may be caught on components and structures within containment, and some debris will accumulate on the sump screen. The assumption of 100% bypass is conservative.

A 50% fiber bypass was assumed for the ex-vessel downstream evaluations. This assumption is essentially double than assumed in Appendix D. Fiber bypass assumed in Appendix D was determined from a review of MUAP-08001, US-APWR Sump Strainer Performance and USNRC NUREG/CR-6885, Screen Penetration Test Report. The assumption was doubled for the ex-vessel evaluations for conservatism.

The ex-vessel downstream effects evaluation assumes that 5% of the reflective metal insulation (RMI) within the Zone of Influence (ZOI) bypass is reduced to fines smaller that 110% of the sump screen opening (0.066 inches) and that 100% of this amount stays in solution and passes through the sump screen. No credit is assumed for settling or capture by the sump screen. This is conservative in that some RMI may not transport, some debris may settle due to low velocities in the RWSP and in the reactor vessel, some debris may be caught on components and structures within containment, and some debris will accumulate on the sump screen. RMI typically fails as metal pieces not as fines. The RMI does not readily transport. The conservative assumption of a 5% fines bypass was chosen to bound all current studies on RMI and RMI transport.

**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.

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**QUESTION NO.: 06.02.02-46**

The MUAP-08013-P report provides a methodology for evaluating plugging and wear of ex-vessel downstream components for the US-APWR design, but it is not directly referenced for the purpose of providing such methods in the FSAR. The proposed evaluation methodology should be provided in Chapter 6 of the FSAR in a manner such that it is clear that it must be used for evaluating these effects for components in the downstream paths that have not yet been designed or selected. Provide a reference to the report in Chapter 6 of the FSAR or otherwise provide the proposed methodology and criteria in the FSAR for evaluation of ex-vessel downstream effects.

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**ANSWER:**

MUAP-08013 will be listed in DCD Chapter 6 as reference 6.2-36. DCD Section 6.2.2.3, paragraph 5, bullet 7 will be modified as follows:

> Downstream effects potentially impacting the safety functions associated with pumps, valves, heat exchangers, instrumentation (sensing lines and flow measuring devices), spray nozzles, reactor vessel flow paths. Evaluation of downstream effects is described in the report "Sump Strainer Downstream Effects" (Ref: 6.2-36).

The following paragraph will be added to DCD Section 6.3.2.2.4:

> The Sump Strainer Performance Evaluation document (Ref. 6.2-34) evaluates parameters described in NEI 04-07 (Ref. 6.2-24). Reference 6.2-36 provides additional detailed evaluation of downstream effects potentially impacting the safety functions associated with pumps, valves, heat exchangers, instrumentation (sensing lines and flow measuring devices), spray nozzles, reactor vessel flow paths. Evaluation of downstream effects is described in the report "Sump Strainer Downstream Effects" (Ref: 6.2-36)

**Impact on DCD**

DCD Subsection 6.2.2.3, paragraph 5, bullet 7 will be modified as follows:

> Downstream effects potentially impacting the safety functions associated with pumps, valves, heat exchangers, instrumentation (sensing lines and flow measuring devices), spray nozzles, reactor vessel flow paths. Evaluation of downstream effects is described in the report "Sump Strainer Downstream Effects" (Ref: 6.2-36).

The following paragraph will be added to DCD Subsection 6.3.2.2.4:

The Sump Strainer Performance Evaluation document (Ref. 6.2-34) evaluates parameters described in NEI 04-07 (Ref. 6.2-24). Reference 6.2-36 provides additional detailed evaluation of downstream effects potentially impacting the safety functions associated with pumps, valves, heat exchangers, instrumentation (sensing lines and flow measuring devices), spray nozzles, reactor vessel flow paths. Evaluation of downstream effects is described in the report "Sump Strainer Downstream Effects" (Ref: 6.2-36)

The following reference will be added to DCD Subsection 6.2.9:

6.2-36 US-APWR Sump Strainer Downstream Effects, MUAP-08013-P, Rev. 0, (Proprietary), and MUAP-08013-NP, Rev. 0, (Non-Proprietary), December 2008.

**Impact on COLA**

There are no impacts on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**QUESTION NO.: 06.02.02-47**

The MUAP-08013-P report provides a list of necessary "confirmation items" that need to be considered in the design, procurement, and installation/layout of the ECCS and CSS components. These items include necessary evaluations of component wear that will need to be completed after specific components are identified, but do not address needed evaluations of component plugging. The report states that verification that the system components will meet needed specifications is considered part of the COL items in FSAR Section 17.4.9. However, the above referenced COL items address the need to develop and implement reliability assurance programs, but do not address the specific need to perform detailed evaluations of ex-vessel downstream components for plugging and wear. Therefore, COL items need to be provided in Chapter 6 that specifically require COL applicants to perform the necessary evaluations of plant-specific components for plugging and wear. Provide COL items in Chapter 6 that address the necessary evaluation of plant-specific components.

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**ANSWER:**

As stated in Section 3.7 of MUAP-08013, Reliability of the ECCS and CSS are considered in the design, procurement, and installation/layout of components and verification that the system components will meet their design specifications is considered part of the COL (DCD Subsection 17.4.9). These activities to confirm these items are included in QA activities described in Subsection 17.4.9. So, MHI think these are not needed to include COL items.

**Impact on DCD**

There are no impacts on the DCD.

**Impact on COLA**

There are no impacts on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**QUESTION NO.: 06.02.02-48**

The MUAP-08013-P report provides an assessment of the debris settling in the downstream components based on the assumed system flow rates following a design basis LOCA compared to the maximum settling velocities. The applicant needs to provide additional information to allow the staff to review the effects of ECCS and CSS fluid flow velocities which could be less than the minimum value required to prevent settling of suspended debris in the downstream flow path. For flow velocities less than the required minimum value (e.g. during system flow initiation or realignment), there is a concern that significant debris settlement could occur that would restrict necessary system cooling flow. For flow velocities less than the required minimum value (e.g. during system flow initiation or realignment), please address whether significant debris settlement could occur causing a restriction of the necessary system core cooling flow.

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**ANSWER:**

Flow rates less than the minimum pump flows referenced in DCD Chapter 6 are not expected. The SIS and CSS are not throttled during post-LOCA operation. In addition, the settling rate evaluation assumed conservative flow rates 15 to 25% lower than those referenced in DCD Chapter 6.

During system flow initiation following a LOCA, the SIS and CSS are operating under clean water conditions i.e. initial suction from the RWSP. The systems are not re-aligned post-LOCA such that a system either stops or starts. The only system realignment following a LOCA is hot leg injection switchover. This realignment operation does not cause the debris settling in the downstream components because safety injection pumps are not required to stop during this realignment operation (as minimum flow lines are always open, there are flows in SIS piping) and duration of this operation which is needed only two valves operation is not long.

Therefore, there will not be significant debris settlement that could occur causing a restriction of the necessary system core cooling flow.

**Impact on DCD**

There are no impacts on the DCD.

**Impact on COLA**

There are no impacts on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**QUESTION NO.: 06.02.02-49**

Provide an evaluation of the potential effects of the settlement or precipitation of boric acid and other chemicals causing blockage of the downstream ex-vessel flow path. In addition to the flow path leading to the reactor vessel, address the effects of entrained debris, boric acid, and other chemicals in carryover liquid exiting the core that could settle or precipitate in the flow path downstream of the reactor vessel (i.e., the flow path from the vessel back to the break location.)

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**ANSWER:**

Boric acid precipitation in the core is prevented by hot leg injection switchover following a cold leg break LOCA. It does not occur following a hot leg break LOCA since boric acid water into the core is discharged to the break location. Should this concentrated fluid exit the core and the assumed break, it will mix with and be diluted by the recirculation volume. Boric acid precipitate will then likely dissolve back into solution. As stated in MUAP-08013 Sections 3.3.6 and 3.4.4:

> "Precipitates and other chemical forms present as a result of the chemical effects testing have no effect on the plugging or wear evaluations.
>
> Chemicals and precipitates are typically soft, non-abrasive, low-shear and readily stay in solution due to the fully developed turbulent flow conditions present within the piping system(s). As such, they do not contribute to plugging or change wear characteristics of piping, pump, heat exchangers or valves downstream of the containment sump."

The same logic and conclusions apply to piping upstream of the containment sump. Therefore potential effects of the settlement or precipitation of boric acid and other chemicals causing blockage of the downstream ex-vessel flow path are minimized.

**Impact on DCD**

There are no impacts on the DCD.

**Impact on COLA**

There are no impacts on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**QUESTION NO.: 06.02.02-50**

Provide an evaluation of the effects of the possible collection of non-condensable gases in high points in the ECCS and CSS flow paths, including gases which may be entrained or evolve out of solution in the recirculation water, chemicals that become gaseous, and gases which may form as a result of chemical reactions. Gases in sufficient quantities that collect and are trapped at high points could cause unacceptable pressure losses and restriction of system cooling flows.

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**ANSWER:**

As stated in Section 3.4.2 of MUAP-08013, reliability of the SIS and CSS are considered in the layout of installation of components. DCD Chapter 17, Subsection 17.4.9 discusses Quality Assurance during design and construction.

**Impact on DCD**

There are no impacts on the DCD.

**Impact on COLA**

There are no impacts on the COLA.

**Impact on PRA**

There is no impact on the PRA.

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**QUESTION NO.: 06.02.02-51**

The MUAP-08013-P report states that the potential for CSS spray nozzle plugging by debris is low. However, the performance of the spray nozzles in accomplishing their necessary safety functions may be affected by changes to the CSS fluid physical or chemical properties, even though the flow rate through the nozzles is not restricted. Provide an evaluation of the effects of entrained debris, chemicals, and gases on the performance of the CSS spray nozzles, especially regarding their effects on spray droplet size distribution for containment pressure suppression and removal of fission products from the containment atmosphere. Provide test data or other empirical evidence as a basis for evaluating the effects on the spray characteristics.

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**ANSWER:**

As stated in DCD Section 6.2.2.2.4 the containment spray nozzles are each fitted with a 0.375 in. orifice. DCD Figures 6.2.2-4, 6.2.2-5 and 6.2.2-6 show typical spray patterns and typical spray coverage. The wear of the CSS spray nozzle orifices will occur over time. For example, after 24 hours, the nozzle orifice diameter may open approximately from 0.375 inches to 0.378 inches. Note that the spray pattern and coverage are considered typical; and this small change in opening diameter will have minimal effect on spray function.

The effect of opening orifice size will be to retain entrained gas in solution, since the local pressure drop would be slightly reduced. The net effect is a more even flow through the nozzle.

Entrained debris and chemical precipitates will have a negligible effect on the operation of the spray nozzles. As stated in MUAP-08013 Sections 3.3.6 and 3.4.4: "Chemicals and precipitates are typically soft, non-abrasive, low-shear and readily stay in solution due to the fully developed turbulent flow conditions present within the piping system(s)." The entrained particles are minute in size and as stated in MUAP-08013 Section 3.3.4 will not plug. Therefore, the small amount of entrained debris will have a minimal effect on spray function.

**Impact on DCD**

There are no impacts on the DCD.

**Impact on COLA**

There are no impacts on the COLA.

**Impact on PRA**

There is no impact on the PRA.