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September 22, 2011

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-11322

Subject: **MHI's Response to US-APWR DCD RAI No. 815-5986 Revision 3 (SRP 06.03)**

Reference: [1] "Request for Additional Information No. 815-5986 Revision 3, SRP Section: 06.03 – Emergency Core Cooling System –Application Section: 6. 3." dated August 23, 2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 815-5986 Revision 3".

Enclosed is the response to Question 06.03-102 that is contained within Enclosure 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.

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NRO

Enclosures:

1. Response to Request for Additional Information No. 815-5986 Revision 3

CC: J. A. Ciocco
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Docket No. 52-021
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Enclosure 1

UAP-HF-11322
Docket No. 52-021

Response to Request for Additional Information
No. 815-5986 Revision 3

September, 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/22/2011

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.:	**NO. 815-5986 REVISION 3**
SRP SECTION:	**06.03 – Emergency Core Cooling System**
APPLICATION SECTION:	**6.3**
DATE OF RAI ISSUE:	**8/23/2011**

QUESTION NO.: 06.03-102

The calculation for the delay time for debris reaching the RWSP in Appendix E of MUAP-08013 Rev. 1 has the following seeming non-conservatisms: neglecting the RCS and accumulator volumes, the possibility of not filling or bypassing ineffective pools, the possibility of reduced return flow to the RWSP and the inclusion of minimum water level (margin for design basis). In light of these seeming non-conservatisms, justify the calculational methodology used for determining the delay time.

ANSWER:

Neglecting RCS and accumulator volume is not conservative for calculating the time delay for debris to reach the reactor vessel after the beginning of a LBLOCA, as indicated in the RAI question. However, MHI believes that this non-conservativeness can be accounted for by the overall factor of safety of 2 applied to the evaluation. That is, although MUAP-08013, Rev. 1, calculated approximately 1,700 seconds for the delay time, the downstream evaluations used 850 seconds for the delay time.

However, the overall methodology was not clearly explained in MUAP-08013, Rev. 1. Therefore, MHI will revise the evaluation methodology and explanation as discussed below. The next revision of Appendix E of MUAP-08013 "US-APWR Sump Strainer Downstream Effects" will be modified per the revised methodology below.

<u>Revised Evaluation Methodology for In-Vessel Debris Arrival Time</u>

1. Introduction

The debris that potentially impacts downstream components of the US-APWR is generated upstream of the sump strainer located in the refueling water storage pit (RWSP). The RWSP is provided as the water source for long-term core cooling after a LOCA, and is located at the bottom elevation of containment in order to collect containment spray and blowdown water by gravity.

The sump strainer system is designed to filter the debris transported to the RWSP (Ref. 1). However, a certain amount of fine debris may pass through the perforated plate of the strainer system and potentially move downstream into the system to reach the reactor vessel (in-vessel).

The purpose of this evaluation is to calculate the time required for the debris to reach the reactor vessel after the accident. An additional factor of safety is applied to the final delay time values used for the downstream evaluations as provided in MUAP-08013 "US-APWR Sump Strainer Downstream Effects".

2. Debris Transport

Immediately after a LBLOCA, blowdown water released from a reactor coolant pipe flows to the bottom floor of the SG compartment together with debris generated by the jet from the pipe break. Next, the water is distributed over the 2nd floor of the PCCV and flows through a labyrinth shield with a slope of 2 inches. Finally, the water and debris flow into the RWSP through 18-inch drain pipes.

In the meantime, SI pumps and CS/RHR pumps are actuated following the LBLOCA and begin to transfer the RWSP water to the DVI lines and the containment spray nozzles. The water injected into the reactor vessel through the DVI lines or dispersed from the spray nozzles eventually returns to the RWSP through several routes.

Although part of the break water with entrained debris might mix in the RWSP, the debris is assumed to arrive at the strainer after most of the initial RWSP water volume passes through the strainer for the following reasons:

- Of the debris transported to the RWSP, relatively large debris will settle and deposit on the bottom of the RWSP or otherwise not bypass the strainer.
- Smaller particulate or fibrous debris is assumed to mix with the initial RWSP water in a similar manner to the blowdown water carrying the debris. Because of the following reasons, the blowdown water carrying debris will stay near the surface of the RWSP:
    - The blowdown water is at a higher temperature than the RWSP water. This difference is assumed to be 90 °F (Tentative value) or more. Therefore, the density of blowdown water is much lower than initial RWSP water.
    - Since the exit of the drain pipes is designed to be submerged 3'-6" beneath the 100 % RWSP water level, almost all of the blowdown water momentum at the end of the exit of the drain pipes is vertical. In other words, the turbulence at the RWSP water surface near the drain pipes is not as significant as the blowdown water momentum.
- Since the sump strainer is located on the bottom of the RWSP approximately 16 feet below the initial water surface, the RWSP water near the bottom of the pit will flow through the strainer first.
- Since the total flow rate of the ECCS (15,960 gpm or 35.56 ft^3/sec) is small in comparison to the initial RWSP volume (76,600 ft^3 at 96% water level), the flow velocity of the RWSP water is very low.

3. Assumptions and Evaluation Mode

The following assumptions were used in the evaluation:

- The RCS blowdown water is released to the SG compartment and then flows out to the aisle area on the 2nd floor of containment above the RWSP before draining to the RWSP through the 18-inch drain pipes.
- The blowdown water and entrained debris which flows into the RWSP through the drain pipes does not significantly mix with the initial RWSP water volume, as discussed in Section 2. Therefore, the water with debris is assumed to arrive at the strainer after the initial RWSP water volume flows through the strainer.
- The initial RWSP water volume is based on the water volume between the technical specification minimum (96% water level) and the top of the strainer.
- The debris arrives at the reactor vessel immediately after passing through the strainer.

4. Calculation

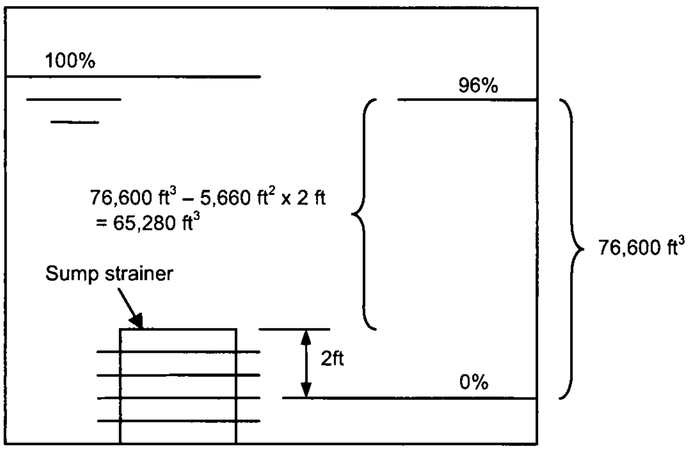

Figure 1: RWSP Water Level Sketch

0% to 96% water level	76,600 ft^3	(Table 6.2.1-3 of Ref. 2)
0% water level to top of strainer	2 ft	(Figure 6.2.1-11 of Ref. 3 with Figure 2-1 of Ref. 1)
Effective area of RWSP	5,660 ft^2 (8.15x10^5 in^2)	(Table e-1 of Ref. 4)
Tech Spec minimum water level	96 %	(Ref. 3)
Strainer suction flow (4 train total)	15,960 gpm = 35.56 ft^3/sec	

Water volume between top of strainer and Tech Spec minimum level:

$$V = 76{,}600\ ft^3 - 5{,}660\ ft^2 \times 2\ ft$$
$$= 65{,}280\ ft^3$$

Debris transportation time:

$$T = 65{,}280\ ft^3 / 35.56\ ft^3/sec = 1835\ sec$$

5. Conclusion

Although the calculated delay time for the generated debris to reach the reactor vessel is approximately 1,800 seconds as discussed in Section 4, **850 seconds** was adopted for the downstream evaluations to account for uncertainties.

6. References

1) Mitsubishi Heavy Industries, LTD., US-APWR Sump Strainer Performance, MUAP-08001 Revision 5, August 2011.
2) US-APWR DCD (Revision 3) GSI-191 Tracking Report, (August 2011 Version), Transmittal No. UAP-HF-11287, August 31, 2011.
3) "Design Control Document for the United States Advanced Pressurized Water Reactor" (Revision 3), Mitsubishi Heavy Industries, Ltd., Docket No 52-021.
4) MHI's Amended Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02), Transmittal No. UAP-HF-11280, August 2011.

Impact on DCD

There is no impact on the DCD.

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.