MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

January 31, 2012

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-12021

Subject: **MHI's Response to US-APWR DCD RAI No. 839-6130 Revision 3 (SRP 06.02.02)**

Reference: [1] "Request for Additional Information No. 839-6130 Revision 3, SRP Section: 06.02.02 – Containment Heat Removal System –Application Section: 6.2." dated October 14 2011.

[2] MHI Letter UAP-HF-11449, "Updated Closure Plan for Issues Associated with GSI-191 for the US-APWR Design Certification" dated December 21, 2011

[3] MHI Letter UAP-HF-12019 "MHI's Amended Response to US-APWR DCD RAI No. 815-5986 Revision 3 (SRP 06.02.02)" dated January 31, 2012

[4] MHI Letter UAP-HF-12020, "MHI's 2nd Amended Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02)" dated January 31, 2012

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document as listed in Enclosure.

Enclosed is the response to the Non-Public RAI that is follow up question of RAI No. 740-5719 (Reference 4) contained within Reference 1.

The enclosed RAI response regards to GSI-191, and the closure plan (Reference 2) was submitted to the NRC in December 2011. With the closure plan and RAI No. 815-8986 response (Reference 3), design change regarding to the GSI-191 is described, and the enclosed RAI response reflecting the design change.

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 response (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

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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 the submittal. His contact information is below.

Sincerely,

Y. Ogata

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

Enclosure:

1. Affidavit of Yoshiki Ogata

2. Response to Request for Additional Information No. 839-6130 Revision 3 (proprietary version)

3. Response to Request for Additional Information No. 839-6130 Revision 3 (non-proprietary version)

CC: J. A. Ciocco
J. Tapia

Contact Information
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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-12021

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 "Response to Request for Additional Information No. 839-6130 Revision 3" dated January 31, 2012, 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 the unique design and methodology developed by MHI for performing the nuclear design of the US-APWR reactor.

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 development of methodology related to the analysis.

B. Loss of competitive advantage of the US-APWR created by benefits of modeling information.

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 31st day of January, 2012.

Y. Ogata

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

Enclosure 3

UAP-HF-12021
Docket No. 52-021

Response to Request for Additional Information No. 839-6130
Revision 3

January 2012
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2012

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.:	**NO. 839-6103 REVISION 3**
SRP SECTION:	**06.02.02 – Containment Heat Removal System**
APPLICATION SECTION:	**6.2**
DATE OF RAI ISSUE:	**10/14/2011**

QUESTION NO. : 06.02.02-69

Follow-up to RAI 740-5719 response and Revision 5 of MUAP-08001:

Request MHI clarify how the RWSP minimum volume margin was calculated, as depicted in MUAP 08001-P (R5), Figure 3-11. As part of the response provide the volume of RWSP water from 0% RWSP level to 4 ft. elevation (Min. Water Level Design Basis). How do volumes used to develop the RWSP minimum volume margin account for submerged SSC volumes?

In addition, request MHI clarify if water in transition from the 25' 3" elevation through the ten, 18 inch transfer pipes to the RWSP minimum water level elevation (~ 4 foot elevation) was accounted for in the calculation of "Return Water on the way to the RWSP" (MUAP-08001 Table 3-10)? If this water in transition was not accounted for, provide an update to Table 3-10 and explain how this volume of water impacts the margin depicted in MUAP-08001-P (R5) Figure 3-11?

Reference: MHI's Amended Response to US-APWR DCD RAI No. 740-5719; MHI Ref: UAP-HF-11280; dated August 31, 2011; ML11245A189.

ANSWER:

1. RWSP Minimum Volume Margin and 0-4ft RWSP Volume

See the response to Question No. 06.02.02-70 below for the calculation of the RWSP minimum volume margin of [ ]

RWSP minimum water level is EL. 7'-7" that is 4ft above floor level. And 0% water level is EL.4'-7". Therefore, level difference between 0% - minimum water level is 3 ft. Water volume from 0% to minimum water level could be calculated using the level difference and RWSP surface area as below. The surface area is also shown in response to RAI Question No. 06.02.02-70.

0%-minimum water level volume $= 3\ ft \times 5{,}654\ ft^2$

$= 16{,}962\ ft^3$

2. Submerged SSCs Volume

The sump strainers are located below the RWSP minimum water level. Therefore, the strainer volume does not have impact on minimum water level calculation.

The calculated volume of the SSCs such as platforms, ladders, piping, and supports located above the minimum water level in RWSP is 85.4 ft^3.

As shown in Attachment 1 of the response to Question No. 06.02.02-70 below, the 0-100% RWSP nominal water volume is 84,750 ft^3. Calculated 0-100% RWSP water volume neglecting submerged SSCs is approximately 85,000 ft^3. The actual 0-100% RWSP water volume could be calculated by subtracting the submerged SSC volume from the calculated RWSP volume, which would be about 84,910 ft^3. The actual 0-100% RWSP holdup volume is still larger than the nominal 0-100% water volume. Therefore, accounting for the volume of the submerged SSCs does not impact the RWSP minimum water volume calculation because the calculation uses the "nominal" RWSP water volume.

3. Water Volume in Transition

The water in transition through the ten 18" transfer pipes is no longer a factor because the pipes have been deleted from the design. The new opening to reactor cavity and header compartment was made inside the SG compartments on 2nd floor as shown in Figure 1.

Figure 1: Floor Openings on 2nd Floor

The height of water overflowing the weirs around the floor openings is 4 in. as the water enters the opening. The water thickness along the inside of the opening will be greater at the top of the opening due to gravity and will decrease with the falling height because the flow rate is constant. Therefore, a water thickness of 4 in. is conservatively assumed to exist from the 2nd floor to the lower floor as indicated by red dash line in Figure 2.

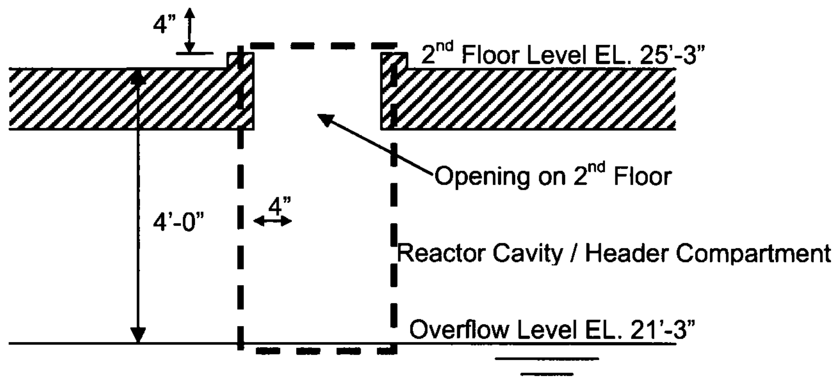

Figure 2: Water Volume Inside Openings on 2nd Floor

The sum of the perimeters of the openings on the 2nd floor is about 100 ft (See Figure 1). So the water volume flowing through the openings is 134 ft^3.
The water volume is account in the "Volume of water in piping and floor opening on 2nd floor" of Attachment 1 of RAI answer to question No. 06.02.02-70.

In addition to water volume in openings on 2nd floor, there are overflow pipes from the reactor cavity and the header compartment to the RWSP. The piping will be filled with water during the post-LOCA condition because the piping becomes a recirculation flow path for water. The piping is filled also with water during normal operation. As illustrated in Figure 3, the overflow piping is filled with water both in the normal condition and the post-LOCA condition. Therefore, the water volume in the overflow piping is neglected from the RWSP minimum water level calculation.

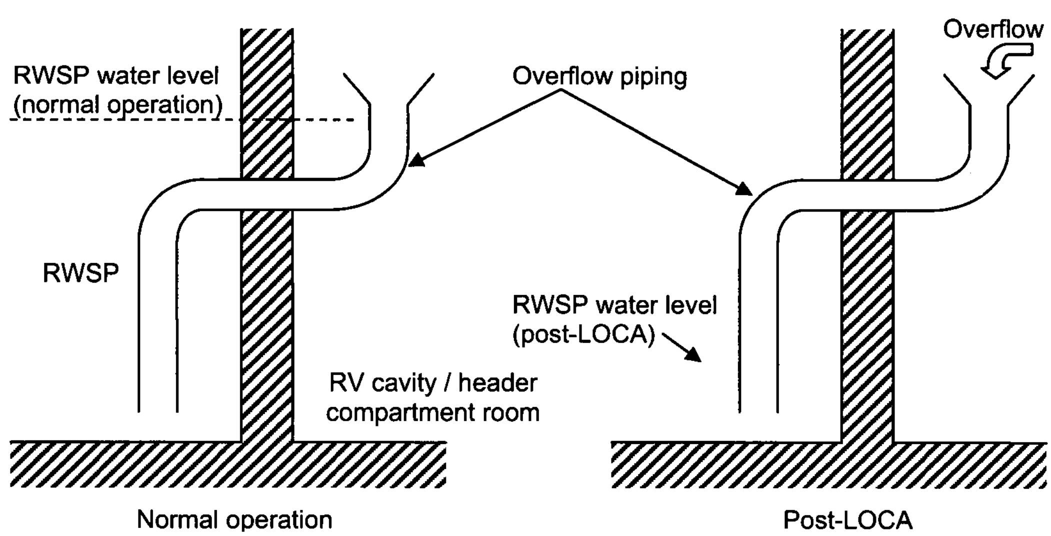

Figure 3: Water in Overflow Piping

4. References

1) Transmittal No. UAP-HF-11449, "Updated Closure Plan for Issues Associated with GSI-191 for the US-APWR Design Certification", December 21, 2011.

Impact on DCD

See note below.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There are impacts on power block layout drawing of Figure 1.2-5R and 1.2-6R, and the contents of the change are same as standard design. Markup drawing of the change will be submitted by end of May 2012 at the same timing with submittal of DCD markup.

Impact on PRA

See note below.

Impact on Technical/Topical Report

See note below.

Note
As described in Section 5 of Ref. 1, summarized change markup of DCD and Technical Report associated with GSI-191 including the RWSP minimum water volume/level calculation shall be submitted to the NRC by end of May 2012.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2012

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.:	**NO. 839-6103 REVISION 3**
SRP SECTION:	**06.02.02 – Containment Heat Removal System**
APPLICATION SECTION:	**6.2**
DATE OF RAI ISSUE:	**10/14/2011**

QUESTION NO. : 06.02.02-70

Follow-up based on RAI 740-5719 response, MUAP-08001-P Revision 5, and GSI-191 tracking report (UAP-HF-11287, dated August 31, 2011):

In MUAP-08001-P (R5) Figure 3-11, MHI depicts margin (volume) existing between the "Min. water level (design basis)" and the "Min water level (calculated)". Given the amount of margin, the staff request that MHI provide the uncertainty associated with "Return Water on the Way to RWSP" and "Ineffective Pools" listed in Table 3-10 of MUAP-08001 (R5) and DCD Table 6.2.1-3 (updated with GSI-191 Tracking report, dated August 31, 2011). As part of the discussion, clarify/explain what approach was used to calculate each volume, for example, a bounding conservative approach, best estimate approach, or combination, and any uncertainties applied to these volumes.

ANSWER:

Figure 1: Water Volume and Water Level of RWSP

References

1) Transmittal No. UAP-HF-11449, "Updated Closure Plan for Issues Associated with GSI-191 for the US-APWR Design Certification", December 21, 2011.

Impact on DCD

See note below.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There are impacts on power block layout drawing of Figure 1.2-5R and 1.2-6R, and the contents of the change are same as standard design. Markup drawing of the change will be submitted by end of May 2012 at the same timing with submittal of DCD markup.

Impact on PRA

See note below.

Impact on Technical/Topical Report

See note below.

Note

As described in Section 5 of Ref. 1, summarized change markup of DCD and Technical Report associated with GSI-191 including the RWSP minimum water volume/level calculation shall be submitted to the NRC by end of May 2012.

Attachment 1: Calculation Summary of Holdup Volume

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2012

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

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SRP SECTION:	**06.02.02 – Containment Heat Removal System**
APPLICATION SECTION:	**6.2**
DATE OF RAI ISSUE:	**10/14/2011**

QUESTION NO. : 06.02.02-71

Follow-up to RAI 740-5719 response:

The water depth on the 25' 3" elevation floor was estimated using the formula, $Q = C*B*h^{3/2}$, which was developed for a rectangular weir geometry (Reference 8 in RAI 740-5719 response). Request MHI justify use of this formula given that MHI has circular weir geometry (transfer pipe configuration).

ANSWER:

As described in the GSI-191 closure plan (Reference 1), the ten 18" transfer pipes on EL. 25'-3" were eliminated and all weirs on the floor became straight weirs. Therefore, the overflow calculation on EL. 25'-3" floor uses the formula for straight weirs.

However, in the design change overflow pipes were installed in the reactor cavity room and the header compartment that allow recirculation water to flow to the RWSP.

Although the weirs of these pipes are curved, MHI decided to use the overflow calculation formula for straight weirs for the overflow height calculation in these rooms for convenience.
The adequacy of using the straight weir formula is described below.

1. Overflow height calculation using straight weir formula

Overflow water level is calculated by the following equation of a straight weir.

$$Q = CBh^{3/2}$$

Where,

$Q = 1.01\ m^3/sec$: over flow quantity
(= SI pump flow + CS/RHR flow)
SI pump flow : 1540 gpm/unit x 4 unit = 6160 gpm = 0.39 m^3/sec
CS/RHR pump flow: 2450 gpm/unit x 4 unit = 9800 gpm = 0.62 m^3/sec

C : flow coefficient
B = 18" diameter × π × 12 pipes: weir width
= 17.2 m
h : overflow height

Assume the overflow height "h" is 0.1m. The overflow piping edge is sharp and it could be assumed that the weir type is a sharp-edge weir. In that condition the flow coefficient C is obtained by equation below.

$C = 1.785 + (0.00295 / h + 0.237 \times h / W) \times (1 + \varepsilon)$
$= 1.842$

Where,
$\varepsilon = 0.55 \times (W - 1)$
W = 1.47 m (58 in): weir height (in header compartment)

Then, the overflow height h is obtained as following.

$h = (Q / (CB))^{2/3}$
$= (1.01 / (1.842 \times 17.2))^{2/3}$
$= 0.101$ m (4 in)

2. Overflow height calculation using curved weir formula

The overflow height for a circular weir could be calculated based on Section 9.26 of Reference 3. Based on this document, the calculation formula is:

$Q = C_0 (2 \pi R_S) H_0^{3/2}$ ---------------------------(1)

Where,
Q = 3 ft^3/sec: Flow rate per one piping
(= 36 ft^3/sec (1.01 m^3/sec) / 12 pipes)
C_0 : Flow coefficient
R_S = 0.75 ft (18 in): Outer radius of weir
H_0 : Partial head on crest
h_a : Overflow head loss
y_S : Nappe height
P = 4.8 ft (58 in): Weir height

MHI used the P/R = 2.0 curve in Figure 9-57 of Ref. 3 because P/R = 6.4 for the US-APWR. Using the smaller P/R curve is more conservative because the smaller P/R value becomes a smaller C_0.

The C_0 value that corresponds to H_0/R_S can be read from Figure 9-57. The flow rate is calculated by substituting the C_0 value to formula (1). The calculated flow rate is 3 ft^3/sec for one pipe in the US-APWR, then the H_0 value will be fixed.

The overflow head loss (h_a) is calculated using the fixed H_0, flow rate, and weir height as follows:

$h_a = V^2 / (2g)$
$= \{Q / (B \times (P + H_0))\}^2 / (2g)$

Where,
B = 1.5 ft × π : Weir length
g = 32.17 ft/sec^2 : Gravitational acceleration

Y/H_S can be read from Tables 9-5 through 9-7 in Ref. 3,, whereY is nappe height and assuming $H_S = H_0$. , The nappe height y_s is calculated using the Y/Hs value.

Overflow height of a circular weir is calculated as follows;

$$h_s = H_0 - h_a + y_s$$

The calculated overflow height based on the US-APWR condition and using the circular weir formula was 2.4in.

3. Conclusion

The calculated overflow height using the straight weir formula was 4 in. and using the circular weir was 2.4 in. Therefore, using the straight weir formula is conservative and MHI will use the straight weir formula for convenience.

4. References

1) Transmittal No. UAP-HF-11449, "Updated Closure Plan for Issues Associated with GSI-191 for the US-APWR Design Certification", December 21, 2011.
2) Rao N.S. Govinda, Muralidhar D. "Discharge characteristics of weirs of finite crest width". J La Houille Blanche 1963;18(5):537–45.
3) United States Department of the Interior, Bureau of Reclamation, "Design of Small Dams", Third Edition, 1987.

Impact on DCD

See note below.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There are impacts on power block layout drawing of Figure 1.2-5R and 1.2-6R, and the contents of the change are same as standard design. Markup drawing of the change will be submitted by end of May 2012 at the same timing with submittal of DCD markup.

Impact on PRA

See note below.

Impact on Technical/Topical Report

See note below.

<u>Note</u>
As described in Section 5 of Ref. 1, summarized change markup of DCD and Technical Report associated with GSI-191 including the RWSP minimum water volume/level calculation shall be submitted to the NRC by end of May 2012.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2012

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.:	**NO. 839-6103 REVISION 3**
SRP SECTION:	**06.02.02 – Containment Heat Removal System**
APPLICATION SECTION:	**6.2**
DATE OF RAI ISSUE:	**10/14/2011**

QUESTION NO. : 06.02.02-72

Follow-up to RAI 740-5719 response:

In the evaluation of the weir overflow height at the transfer pipes, MHI assumes all ten transfer pipes/weirs perform as independent transfer pipes/weirs. However, the pipes are situated in pairs and near RWSP tank walls and other structures. Request MHI provide justification that the transfer pipe weir/curb design, given their proximity to each other and other structures, supports treatment as independent weirs/curbs for the analysis of overflow height.

ANSWER:

As described in the GSI-191 closure plan (Reference 1), the ten 18" transfer pipes have been deleted from the design.

Two openings on the 2nd floor discharging to the reactor cavity are close each other and to walls (See Figure 1). MHI conservatively assumed that only one opening is available (i.e., considered only one opening length as the weir length that is used for the overflow height calculation). The proximity effect was evaluated as shown below to prove the adequacy of the assumption.

Figure 1 Neighboring Two Openings

MHI modeled the two openings and the surroundings as illustrated in Figure 2. The pressure loss at the narrow point of water flow path was calculated and the effect was evaluated using the model.

1. Conditions and Assumptions

The conditions and assumptions used to evaluate the effect are:

<u>Conditions</u>

- Flow rate:	0.162 m^3/sec (1.01 m^3/sec × 16%) Where, 1.01 m^3/sec: SI and CS/RHR pump flow (Total 15,960 gpm) 16%: Flow ratio to one opening
- Height of weir:	0.05m (2 inches)
- Length of weir:	0.15m (6 inches)
- Water depth in front:	0.15m (6 inches)

<u>Assumptions</u>

Figure 2 Model around Openings on 2nd Floor (Plan View)

Figure 3 Model around Openings on 2nd Floor (Section View)

2. Calculation

3. **Evaluation**

4. **References**

1) Transmittal No. UAP-HF-12020 "MHI's 2nd Amended Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02)", January 31, 2012.

Impact on DCD

See note below.

Impact on R-COLA

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Impact on S-COLA

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See note below.

Impact on Technical/Topical Report

See note below.

Note
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US-APWR Design Certification
Mitsubishi Heavy Industries, Ltd.
Docket No. 52-021

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APPLICATION SECTION:	**6.2**
DATE OF RAI ISSUE:	**10/14/2011**

QUESTION NO. : 06.02.02-73

Follow-up to RAI 740-5719 response:

During a design basis accident, water spilled from the reactor and from containment spray can collect (pool) on floors inside containment. The 25' 3" elevation floor, often referred to as the 2nd floor, contains the floor inside the SG compartment and the floor outside the SG compartment. MHI calculates a water height on the floor outside the SG compartment and applies this water height to the entire 2nd floor. The staff request that MHI provide justification that use of a water height calculated from outside the SG compartment is appropriate for use on the floor inside the SG compartment. As part of the response, provide the method of analysis, inputs and assumptions, and justification for their selection.

ANSWER:

As the staff indicated, the water height outside the SG compartments ("outside") and inside the SG compartments ("inside") during an accident will differ due to the pressure loss at the narrow entrance.

1. Conditions

Due to the design change described in Reference 1, water flow path changed as shown in Figure 1. After the design change, spray/blowdown water will flow from "inside" to the RWSP through the reactor cavity or the header compartment and there is no direct flow path from "outside" to RWSP. Spray water coming to the "outside" will flow to the "inside" through four narrow entrances located in the secondary shield wall at 45, 135, 225 and 315 degrees. Water coming to the "outside" will be about 30% of the total spray flow, because most of spray drops on 4th floor and the dropped water goes to the "inside" through four large openings on 4th floor above the reactor coolant pumps. The flow rate from "outside" to "inside" is:

Flow rate from "outside" to "inside" through one entrance = 0.62 m^3/sec (9800gpm) × 30% / 4
= 0.0465 m^3/sec (approx. 1.6 ft^3/sec)

Figure 1: Water Flow Path Model (Post-LOCA)

Figure 2 shows the path from "outside" to "inside". Although there is a 2 in. weir along the flow path.

Figure 2: Model of Water Depth Difference between "Inside" and "Outside"

2. Calculations

3. Summary

4. References

1) Transmittal No. UAP-HF-11449, "Updated Closure Plan for Issues Associated with GSI-191 for the US-APWR Design Certification", December 21, 2011.
2) Transmittal No. UAP-HF-12020 "MHI's 2nd Amended Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02)", January 31, 2012.

Impact on DCD

See note below.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

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Impact on PRA

See note below.

Impact on Technical/Topical Report

See note below.

Note

As described in Section 5 of Ref. 1, summarized change markup of DCD and Technical Report associated with GSI-191 including the RWSP minimum water volume/level calculation shall be submitted to the NRC by end of May 2012.