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

May 30, 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-12126

**Subject: MHI's 3rd Amended Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02)**

**References:**
[1] "Request for Additional Information No. 740-5719 Revision 2, SRP Section: 06.02.02 – Containment Heat Removal System –Application Section: 6.2." dated April 26, 2011 (ML111160564).
[2] MHI Letter UAP-HF-11181, "MHI's Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02)" dated July 14, 2011 (ML11168A008).
[3] MHI Letter UAP-HF-11280, "MHI's Amended Response to US-APWR DCD RAI No. 740-5719 Revision 2 (SRP 06.02.02)" dated August 31, 2011 (ML11245A189).
[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 (ML12033A284).
[5] MHI Letter UAP-HF-12131, "MHI's 2nd Amended Response to US-APWR DCD RAI No. 815-5986 Revision 3 (SRP 06.03)" dated May 2012.
[6] MHI Letter UAP-HF-12127, "MHI's Amended Response to US-APWR DCD RAI No. 839-6103 Revision 3 (SRP 06.02.02)" dated May 2012.
[7] MHI Letter UAP-HF-12128, "MHI's Response to US-APWR DCD RAI No. 921-6415 Revision 0 (SRP 06.02.02)" dated May 2012.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "3rd Amended Response to Request for Additional Information No. 740-5719 Revision 2 (SRP 06.02.02)". In Reference 2, MHI provided the original response to the NRC's Request for Additional Information ("RAI") in Reference 1. This response was subsequently amended by References 3 and 4, respectively.

Enclosed is the 3rd amended response to Question 06.02.02-64 that is contained within Reference 1. This response supersedes the previous responses which were transmitted in References 2, 3 and 4 in their entirety.

The enclosed RAI response is related to the hold-up water volume calculation related to GSI-191. MHI changed the design of the recirculation water flow path under post-LOCA conditions, as described in response to RAI 815-5986 in Reference 5, after the RAI in Reference 1 was issued. In order to appropriately reflect the design change, the response to RAI 740-5719 was revised (see Enclosures 2 and 3). With regard to the hold-up volume calculation, two other RAI responses are being transmitted with the same timing as this letter in order to appropriately reflect the design change of the recirculation flow path (References 6 and 7).

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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) of the response, a copy of the non-proprietary version (Enclosure 3) of the response, 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.

Sincerely,

Y. Ogata

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

Enclosures:

1. Affidavit of Yoshiki Ogata

2. 3rd Amended Response to Request for Additional Information No. 740-5719 Revision 2 (SRP 06.02.02) (proprietary version)

3. 3rd Amended Response to Request for Additional Information No. 740-5719 Revision 2 (SRP 06.02.02) (non-proprietary version)

CC: J. A. Ciocco
J. Tapia

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# Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-12126

**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 "3rd Amended Response to Request for Additional Information No. 740-5719 Revision 2 (SRP 06.02.02)" dated May 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 30th day of May, 2012.

Y. Ogata

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

Enclosure 3

UAP-HF-12126
Docket No. 52-021

3rd Amended Response to Request for Additional Information
No. 740-5719 Revision 2

May 2012
(Non-Proprietary)

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**5/29/2012**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries, Ltd.**

**Docket No. 52-021**

| | |
|---|---|
| **RAI NO.:** | **NO. 740-5719 REVISION 2** |
| **SRP SECTION:** | **06.02.02 – Containment Heat Removal System** |
| **APPLICATION SECTION:** | **6.2** |
| **DATE OF RAI ISSUE:** | **4/26/2011** |

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**QUESTION NO.: 06.02.02-64**

On April 7th, 2011, the staff performed an audit of 4CS-UAP-20070029 Rev1, "Hold-up Water volume calculation sheet during LOCA" describing the calculation of hold-up water volume following a loss of coolant accident to be used in determining the NPSH available for safety related pumps that draw suction from the RWSP. Describe how this calculation was conservative for the NPSH evaluation. Include the following considerations.

a. The NaTB baskets and associated drain piping were not discussed in the hold-up volume calculation.
It appears that they should be as they are designed to collect spray water and then deliver flow to the RWSP.

b. Appropriate reference and justification should be provided for the applied methodology and selected input values used in the hold-up water calculation to demonstrate how the hold-up amount is conservative from a NPSH perspective. The following areas require additional information:

- o Containment spray water droplets – Amount of water is a function of flow volume, fall height, and fall time. Method used for evaluating the fall time did not consider atmospheric resistance. This method under-predicts the fall time and therefore the spray water hold-up in the atmosphere. In addition, the flowrate and fall height values selected were not referenced to a document nor was a description provided that explained why the selected values were conservative for calculating hold-up amounts. Please explain how the treatment of spray water droplets in your calculation will provide conservative results.

- o Condensate water on containment surfaces – Equation listed for film condensation correlation used to calculate film thickness could not be readily verified (reference in Japanese) and was not found in standard textbooks on heat and mass transfer. Appropriate reference and justification should be provided for the applied methodology and selected input values. Film thickness will be a function of the surface height. Justify estimated vertical surface area and corresponding heights used in the calculations.

o Vapor in the containment atmosphere – No basis provided for vapor amount assumed in the hold-up analysis. Please provide the reference and basis for the atmospheric conditions used to calculate the vapor amount.

o Water retained on the floors – Reference and basis was not provided for selected equation (method of evaluation) or input values used to evaluate dynamic retention on containment floor (result was 6" water height above floor). No evaluation was provided for assessing the dynamic retention on upper floors in containment (assumed 2" height above floor). Please provide the reference and basis and for calculating the dynamic water retention heights to include method and input values.

c. Describe how the volume of water in the reactor system and the volume of water re-injected into the reactor system from the safety injection system is evaluated.

d. Provide a proposed ITAAC for inspection of the as built containment. The purpose of the inspection is to confirm that all potential water retention locations have been identified and the amount of water retention has been conservatively estimated for each potential location.

e. Provide a correlation to permit converting RWSP water volume (gallons) to RWSP water level (feet).

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**ANSWER:**

**a. Hold-up volume of NaTB baskets and associated drain piping**

The calculation will be revised to account for the NaTB basket and piping volumes in the total "Hold-up Volume".

- NaTB baskets: 2,950 $ft^3$ (Ineffective Pool)
  (5% manufacturing error was considered as uncertainty)
- Associated drain piping: 160 $ft^3$ (Return Water on the Way to RWSP)

The water volume associated with the drain piping is accounted for as part of the "Volume of water in piping and floor opening on 2nd floor" shown in Attachment 1 of the response to question No. 06.02.02-70 (Reference10).

The overall impact of this change is discussed in the "Summary" at the end of this response.

**b. Clarification of hold-up water calculations and related references**

- Containment spray water droplets

  The terminal velocity of containment spray droplets was re-calculated under the assumptions for the accident fluid condition in the containment with different elevations as described in Table b-1. As a result, the calculated fall times in the containment atmosphere above the operating floor are approximately 10 sec to 25 sec considering atmospheric resistance as a function of Reynolds number.

  Spray droplet terminal velocity and fall time within the containment dome atmosphere were calculated in the following manner.

For the transition and turbulent region (500 < Re <1.0 × $10^5$), the resistance coefficient for a spherical shape is defined as:

$C_D = 0.44$ (Ref. 1)

Since Re for this calculation case is above 500, terminal velocity can be calculated as follows:

$$m\frac{dv}{dt} = mg - D$$

where *m* is the droplet mass for one particle, *v* is particle velocity, *D* is resistance force and *g* is gravitational acceleration. *D* can be derived from Stokes law with $C_D$ for the transition and turbulent region as

$$D = \frac{1}{2}C_D \rho v^2 S = 0.22\rho\pi r^2 v^2$$

where $\rho$ is the containment atmospheric density, $\mu$ is viscosity and *S* is particle surface area (cross section normal to velocity).

Terminal velocity *v* can be derived from the above equations by assuming free fall as:

$$v = \sqrt{\frac{mg}{0.22\rho\pi r^2}}.$$

Then, the fall time *t* for the transition and turbulent regions ( $C_D = 0.44$ ) can be solved for the different elevations as shown in Table b-1.

For the fall time calculation, since the droplet reaches terminal velocity quickly, it is possible to simply apply the $C_D$ for the transition and turbulent regions and neglect $C_D$ for the laminar region. Based on the obtained fall times (about 16 seconds to operating floor and about 20 seconds to refueling cavity floor), the total spray water droplet volume was calculated to be about 2,640 gallons.
The "Return Water on the Way to RWSP" volume in DCD Table 6.2.1-3 will be revised to reflect a total of 2,640 gal.

The overall impact of this change is discussed in the "Summary" at the end of this response.

**Table b-1 Calculation Assumptions**

| Parameter | Description | Value |
|---|---|---|
| Spray Droplet Shape | Sphere | N/A |
| Spray Droplet Diameter | Constant to Sauter mean diameter | 1,000 micro meters (Ref. 2) |
| Initial Speed | Not Considered | 0 |
| Spray Nozzle Level | Highest level of spray nozzle | EL 224'-5" |
| Floor Level | Operating floor | EL 76'-5" |
| | Refueling cavity floor | Each refueling cavity floor level (EL 46'-11" etc.) |
| Containment Atmosphere Fluid Condition | LOCA Peak Pressure/Temperature (Mixture of steam, air and nitrogen released from accumulator) | 74.2 psia<br>284 °F<br>(Ref. 3) |

- Condensate water on containment surfaces

Condensate film thickness was calculated from Eq. 11 in the hold-up volume calculation based on the fluid conditions. The calculation follows the methodology of theoretically solving the Nusselt film heat transfer correlation, which is widely known (References 4 and 5).

The steps of deriving Eq. 11 are shown as follows:

Assume constant condensation and liquid flow on structure surfaces (Figure b-1).

Mass Conservation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad \text{(Eq. 1)}$$

Momentum Conservation

$$\rho_L u \frac{\partial u}{\partial x} + \rho_L v \frac{\partial u}{\partial y} = \mu_L \frac{\partial^2 u}{\partial y^2} + g(\rho_L - \rho_v)\sin\varphi \qquad \text{(Eq. 2)}$$

Energy Conservation

$$c_{pL}\rho_L u \frac{\partial \theta}{\partial x} + c_{pL}\rho_L v \frac{\partial u}{\partial y} = \lambda_L \frac{\partial^2 \theta}{\partial y^2} \qquad \text{(Eq. 3)}$$

Where:

- $u$ : Liquid velocity for y axis (horizontal)
- $v$ : Liquid velocity for x axis (vertical)
- $\rho_L$ : Liquid film density
- $\mu_L$ : Liquid film viscosity
- $\rho_v$ : Vapor (steam) density
- $\varphi$ : Heat structure surface angle from horizontal (90°)
- $c_{pL}$ : Liquid film heat capacity
- $\theta$ : Temperature
- $\lambda_L$ : Liquid film heat conductivity

Boundary conditions are as follows:

u=v=0 and $\theta=\theta_W$ at y=0 (structure surface),

$\mu_L \frac{\partial u}{\partial y} = 0$ and $\theta=\theta s$ at $y=\delta$ (film surface) (Eq. 4)

Where

$\theta_w$ : Structure surface temperature

$\theta_s$ : Film surface temperature

Additionally, assuming thermal equilibrium from x=0 to x=x in the liquid film at steady state and condensation latent heat L, energy balances can be written as follows:

$$L\int_0^\delta \rho_L u dy + L\int_0^\delta \rho_L u c_{pL}(\theta s - \theta) dy = \int_0^x \lambda_L \left(\frac{\partial \theta}{\partial y}\right)_{y=0} dx$$

Simplifying gives:

$$L\rho_L \int_0^\delta u\left\{1 + \frac{c_{pL}(\theta s - \theta)}{L}\right\} dy = \lambda_L \int_0^x \left(\frac{\partial \theta}{\partial y}\right)_{y=0} dx \qquad \text{(Eq. 5)}$$

Generally, $\frac{c_{pL}(\theta s - \theta)}{L}$ is much smaller than 1 and thus the thermal conductance in the liquid film can be ignored. This further simplifies Eq. 5 to:

$$L\rho_L \int_0^\delta u dy = \lambda_L \int_0^x \left(\frac{\partial \theta}{\partial y}\right)_{y=0} dx \qquad \text{(Eq.6)}$$

Applying the same assumption to Eq.3, $\frac{\partial^2 \theta}{\partial y^2}$ can be considered very small and therefore assumed to be zero. Integrating Eq. 3 (with $\frac{\partial^2 \theta}{\partial y^2}$ set to zero) and considering boundary conditions, temperature distribution in the liquid film is given as:

$$\theta = \theta_W + (\theta_S - \theta_W)\frac{y}{\delta} \qquad \text{(Eq. 7)}$$

For the momentum conservation, neglecting the kinetic term and assuming no change in velocity (steady state) in Eq. 2, the following equation is obtained:

$$\mu_L \frac{\partial^2 u}{\partial y^2} = -g(\rho_L - \rho_v)\sin\varphi \qquad \text{(Eq. 8)}$$

With integration and boundary conditions, Eq. 8 can be expressed as:

$$u = \frac{g(\rho_L - \rho_v)\sin\varphi}{2\mu_L}(2\delta y - y^2) \qquad \text{(Eq. 9)}$$

In order to obtain the liquid film thickness, combining Eq. 7 and Eq. 8 with Eq. 6 gives:

$$\frac{\delta^3}{3} = \frac{c_{pL}(\theta_S - \theta_W)}{L} \frac{\nu_L \kappa_L}{g\left(\frac{\rho_L - \rho_V}{\rho_L}\right)\sin\varphi} \int_0^x \frac{dx}{\delta} \qquad \text{(Eq. 10)}$$

where $\nu$ is kinetic viscosity and $\kappa$ is thermal conductivity of the liquid.

With an integration and boundary condition δ=0 at x=0, liquid film thickness is given by the following equation:

$$\delta = \sqrt{2}\left\{\frac{c_{pL}(\theta_S - \theta_W)}{L}\right\}^{\frac{1}{4}} \frac{1}{(Gr_x Pr_L)^{\frac{1}{4}}} x \qquad \text{(Eq. 11)}$$

Local heat transfer coefficient for film condensation is calculated from the well-known Nusselt equation which is obtained through the derivative of Eq. 7:

$$h_x = \frac{\lambda_L \left.\frac{\partial \theta}{\partial y}\right|_{y=0}}{\theta_S - \theta_W} = \frac{\lambda_L}{\delta}$$

and substitution into Eq.11:

$$Nu_x = \frac{h_x x}{\lambda_L} = \frac{1}{\sqrt{2}}\left\{\frac{L}{c_{pL}(\theta_S - \theta_W)}\right\}^{0.25} (Gr_x Pr)^{0.25}$$

Condensation liquid thickness on the surface of the heat structure is predicted by Eq. 11. The height used for this calculation was 40 meters (about 130 feet), and the resulting condensation film thickness (based on 40 meters height) was applied to all surfaces. The vertical portion of containment from the second floor level (EL 25'-3") is about 129 feet. If the vertical height (x) increases, the liquid film thickness also increases as shown in Eq. 11. However, the liquid thickness calculated based on a 40 meter height was conservatively applied to all surfaces.

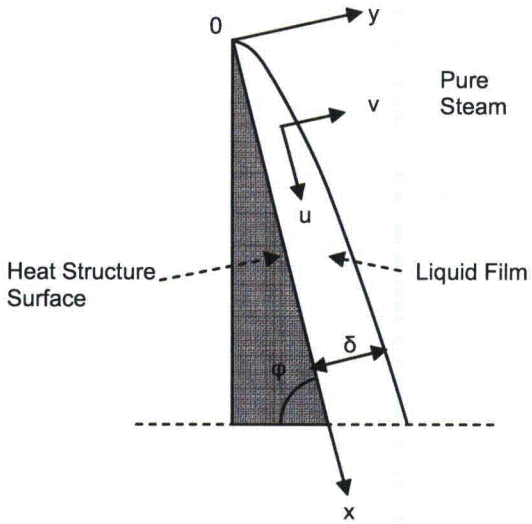


Figure b-1 Film Condensation on Structure Surface

The vertical surface area of the containment was calculated using "Concrete Outline Drawings," which indicate the frame shape of the building and the dimensions, and a 5% margin was added to the total area.

There is no change to the previously calculated RWSP water volumes in DCD Table 6.2.1-3.

- Vapor in the containment atmosphere

  The amount of vapor is calculated from the conditions for the worst case pressure inside containment during a LOCA described in DCD Section 6.2.1. The calculation is based on the mass and energy release during a LOCA as described in DCD Section 6.2.1.3 and Tables 6.2.1-18, 6.2.1-20 and 6.2.1-5 and the assumption of minimum condensation volume as described in DCD Section 6.2.1 and Tables 6.2.1-4 and 6.2.1-5.

  There is no change to the previously calculated RWSP water volumes in the DCD Table 6.2.1-3.

- Water retained on the floors

  Water depth on the floors is calculated based on the following general expressions:

  $$Q = CBh^{3/2} \qquad (1)$$

  Where:
  Q: Overflow volume
  C: Flow coefficient
  B: Length of weir
  h: Overflow height

  Overflow volume is calculated from pump flow rate by conservatively assuming the maximum flow rate considering four train SI and CS/RHR pump operation. The total flow rate is:

  Q = 1,540 gpm (SI pump) x 4 (train) + 2,450 gpm (CS/RHR pump) x 4 (train)
  = 15,960 gpm
  = 1.01 $m^3$/sec

  The flow coefficient was calculated for the weir based on References 7 and 8 as follows:

  C = 1.444 + 0.352(h/L)
  = 1.665

  Where, L = 6 in ≈ 0.15 m (Length of weir)
  h = 0.094 m (Assumption value: overflow height)

  Although the condition of the US-APWR exceeds unity as defined in the Reference 7 and 8 documents, using above formula is more conservative. See Reference 12 for the detailed discussion of the conservativeness.

  Total length of the weir is approximately 26.4 m (1,040 in). The weir length was conservatively extracted considering proximity effect that is described in RAI 839-6103 Question No. 06.02.02-72 (Reference 10). See Figure b-2 for the 2nd floor opening sizes. Although a debris interceptor is installed at the each of the openings or below the openings on the 2nd floor, it was conservatively assumed that 20% of weir length is blocked. Assuming complete blockage of one opening, a maximum of about 14% length of weir will be blocked. Therefore, the 20% blockage assumption is sufficiently conservative.

Figure b-2 Floor openings on 2nd floor

Then, the length of the weir is:

$B = 26.4\ m \times 80\%$

$= 21.12\ m\ (832\ in)$

From Eq. (12) the overflow height is determined as follows:

$h = (Q / (C \times B))^{2/3}$

$= (1.01 / (1.665 \times 21.12))^{2/3}$

$= 0.094\ m$

$\approx 0.1\ m$ (Roundup)

$\approx 4\ in$

The above overflow level calculation can only be applied inside the SG compartment room on the 2nd floor. The over flow height will be 1 in higher outside the SG compartment than inside (i.e., 5 in) because the recirculation water flow from outside to inside causes a pressure drop to occur at the narrow entrance. See the response to RAI 839-6103 Question No. 06.02.02-73 in Reference 10 for a detailed calculation of the overflow height of outside the SG compartment room. The response also

describes the sensitivity of the overflow height inside and outside the SG compartment.

Although this overflow level change has an impact on DCD Table 6.2.1-3, there are also other changes due to the response to RAI 839-6103 (Reference 10). Therefore, the overall changes regarding the hold-up volume calculation are summarized in Attachment 1 of the response to RAI 839-6103 Question No. 06.02.02-70.

**c. Reactor system and re-injection water volume**

The overall effects of the RCS and re-injection water volumes are not included in the evaluation, but the effect is conservative based on the following.

Following a LOCA, the reactor system water immediately begins to spill out from the broken pipe section, and flows into the RWSP, raising its water level. Soon afterwards the water in the reactor vessel will be supplemented with the water re-injected by the ECCS. Although the re-injected water is from the RWSP, the RWSP water level will not decrease because the volume of the reactor system water that flows into the RWSP is larger than that of re-injected water. Therefore, if the reactor system water and the re-injected water were taken into account, the RWSP water level would be higher. Consequently, excluding these water volumes results in conservative evaluation of hold-up water in view of minimum water level calculation.

There is no change to the previously calculated RWSP water volumes in DCD Table 6.2.1-3.

**d. ITAAC**

Tier 1 and ITAAC provide top-level information that includes the principal performance characteristics and safety functions of SSC. MHI understands the importance of verifying as-built water retention locations, but considers this to be within the scope of the existing ITAAC.

Inspection of containment after construction to determine if all potential water retention locations have been identified and the amount of water has been conservatively estimated for each potential location, does not meet the SRP 14.3 selection criteria. MHI considers a separate ITAAC for this purpose to represent an inappropriate level of detail and, therefore, to be unnecessary.

US-APWR DCD Revision 3 Tier 1 Table 2.4.4-5 ITAAC #1 verifies ECCS functional arrangement, and ITAAC #7.d verifies adequate safety injection pump available and required NPSH. The verification of NPSH available will include inspection of the as-built containment drawings to verify the hold-up water volumes, in order to confirm the minimum RWSP water level. Therefore, the existing ITAAC adequately verify the water retention locations at the proper level of detail.

**e. Conversion of RWSP water volume to RWSP water level**

The effective area of the RWSP will vary with the height from the bottom of the RWSP (EL 3'-7") since there are an elevator pit and concrete ducts inside the RWSP. Table e-1 shows the relationship between the height from the RWSP bottom and the specific water level increase per gallon.

Table e-1: Height from RWSP Bottom vs. Water Level Increase Ratio

| Height from RWSP bottom | Effective area of RWSP | Water level increase per gallon |
|---|---|---|
| 0 – 12' 2" | $8.15 \times 10^5$ in$^2$ | $2.84 \times 10^{-4}$ in/gal |
| 12' 2" – 15' 11" | $7.19 \times 10^5$ in$^2$ | $3.22 \times 10^{-4}$ in/gal |
| 15' 11' – | $7.06 \times 10^5$ in$^2$ | $3.28 \times 10^{-4}$ in/gal |

There is no change to the previously calculated RWSP water volumes in DCD Table 6.2.1-3. However, the revised RWSP areas above resulted in an increase of 3,000 gallons to the calculated RWSP liquid volume in DCD Table 6.2.1-5.

**Summary**

This RAI response results in an impact on the DCD because the hold-up water volume changed. However, the response to RAI 839-6103 (Reference 10) also impacts the description of the hold-up volume calculation. Therefore, the overall hold-up water volume calculation is summarized in Attachment 1 of the response to RAI 839-6103 Question No. 06.02.02-70 provided in Reference 10. See Reference 11 for a summary of DCD mark-up changes associated with GSI-191 including the hold-up volume calculation.

**References**


1) Bird, Stewart and Lightfoot, Transport Phenomena, Second Edition, p. 187
2) Subsection 6.2.2.3, DESIGN CONTROL DOCUMENT FOR THE US-APWR Chapter 6, Engineered Safety Features, MUAP- DC006 Revision 3, March 2011
3) Table 6.2.1-6, DESIGN CONTROL DOCUMENT FOR THE US-APWR Chapter 6, Engineered Safety Features, MUAP- DC006 Revision 3, March 2011
4) Nusselt, W., Die Oberflachenkondesation des Wasserdamffs the surface condensation of water. Zetrshr. Ver. Deutch. Ing., 60 (1916), 541-546
5) Bird, Stewart and Lightfoot, Transport Phenomena, Second Edition,.p.452
6) MHI Letter No. UAP-HF-12125, MUAP-08001 Revision 6, "US-APWR Sump Strainer Performance", dated May 2012.
7) JIS B8302, Measurement methods of pump discharge, 2002 Edition, Japanese Standards Association.
8) Rao N.S. Govinda, Muralidhar D. "Discharge characteristics of weirs of finite crest width". J La Houille Blanche 1963;18(5):537–45.
9) MHI Letter No. UAP-HF-12131, "MHI's 2nd Amended Response to US-APWR DCD RAI No. 815-5986 Revision 3 (SRP 06.03)", dated May 2012.
10) MHI Letter No. UAP-HF-12127, "MHI's Amended Response to US-APWR DCD RAI No. 839-6103 Revision 3 (SRP 06.02.02)", dated May 2012.
11) MHI Letter No. UAP-HF-12135, "US-APWR DCD GSI-191 Tracking Report", dated May 2012.
12) MHI Letter No. UAP-HF-12128, "MHI's response to US-APWR DCD RAI No. 921-6415 Revision 3 (SRP 06.02.02)", dated May 2012.

**Impact on DCD**

See note below.

**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**

See note below.

Note
Impacts of the response on the DCD and Technical Report due to this response are reflected to the GSI-191 DCD Tracking Report (Reference 11) and the revised Technical Report (Reference 6).