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July 7, 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- 09365

Subject: MHI's Responses to US-APWR DCD RAI No. 354-2585 Revision 0

Reference: [1] "Request for Additional Information No. 354-2585 Revision 0, SRP Section: 06.02.02 – Containment Heat Removal System - Design Certification and New License Applicants, Application Section: 6.2.2 and 6.3," dated May 7, 2009.

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. 354-2585 Revision 0".

Enclosed are the responses to 26 questions that are contained within Reference [1]. Of these questions, 1of RAI not answered in this package. It is Question 06.02.02-44 which requested MHI to provide the additional information with respect to the types of insulation used inside the containment and identify where and in what quantities each type is used. MHI needs additional weeks to complete for estimation of the amount of insulations for each type used in the whole containment. The answer to Question 06.02.02-44 will be provided to the NRC by July 17, 2009.

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. Responses to Request for Additional Information No. 354-2585 Revision 0

CC: J. A. Ciocco
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Contact Information

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Enclosure 1

UAP-HF- 09365
Docket No. 52-021

Responses to Request for Additional Information
No. 354-2585 Revision 0

July 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-19

MHI discusses Break Selection in MUAP 08001-NP Section 3.1. NEI GR discusses break selection as a two step process involving selection of the size of the break and the location. The NRC staff requests that MHI specify the break size selected for primary and secondary line breaks (example, DEGB) and the basis for the break size selected.

ANSWER:

The following is a description of the break size selected for primary and secondary line breaks (example, DEGB):

The break size considered for line breaks (primary and secondary) are double-ended guillotine breaks (DEGB). The basis for this break size selection is to provide the largest volume of debris from insulation and other materials that may be within the region affected by the postulated break.

Section 3.1 of MAUP 08001-NP (R2) will be revised with insertion of the above information after last sentence of first paragraph of Section 3.1

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

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SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-20

MUAP 08001-NP, US-APWR Sump Strainer Performance Report Table 3-1 provides break locations considered but does not provide type and quantity of debris. The NRC staff requests that MHI provide quantitative results that demonstrate a break in the main coolant piping is the limiting break location (worst case) in terms of debris generation, transport, and head loss. Results summary should allow comparison between break locations and include quantity of each debris type generated from each debris location evaluated. Include secondary line breaks (MS/MF) as they require recirculation (sump operation) per MUAP 08001-NP page 10. If more than four break locations evaluated provide data only for the four most limiting locations.

ANSWER:

MHI agrees that Section 3.1 of MUAP-08001(R2) does not provide quantitative results that demonstrate a break in the main coolant piping is the limiting break location (worst case) in terms of debris generation, transport, and head loss, or a results summary providing comparison between break locations and quantity of each debris type generated from each debris location evaluated.

Section 3.1 of MUAP-08001(R2) will be revised to include a discussion of quantitative results that demonstrate a break in the main coolant piping is the limiting break location (worst case) in terms of debris generation, transport, and head loss. Following is a results summary that provides to allow comparison between break locations and quantity of each debris type generated from each debris location evaluated.

The main coolant piping break was selected as the worst case of debris generation due to jet impingement from broken pipe. The other non-chemical debris, such as latent debris and miscellaneous debris were conservatively defined as constant amount as per NEI GR and operating experiences. Therefore, the worst case of debris generation was determined by the break location that generates maximum fibrous insulation debris and RMI debris in the containment.

Since the US-APWR considered that all debris were reachable to the RWSP, it was not needed to select worst break location in terms of debris transport. In addition, each type of debris was combined as design basis debris so as to maximize the strainer head loss.

Following is debris generation calculation including four break locations other than MCP break, in order to demonstrate that MCP break was the worst case of break location.

1. Selection of break pipes and locations

Following break pipes and locations other than MCP breaks were selected to compare its impact on debris generation:

(1) Pressurizer surge pipe (16in) break at MCP nozzle
As a comparative break location with MCP break inside secondary shield walls, Pressurizer surge line pipe break was selected for the evaluation. In results, it was examined that the break location at MCP nozzle generates maximum amount of fibrous debris in the line.

(2) Main steam pipe (32in) break near the containment penetration
As a representative break location outside secondary shield walls, main steam pipe break was selected and examined the break location generating maximum fibrous debris. The selected break point was located above the floor elevation EL 76'-5" outside the secondary shield walls.

(3) Feedwater pipe (16in) break near the containment penetration
Feedwater pipe breaks outside the secondary shield walls were examined. The selected break point was located above the floor elevation EL 50'-2" outside the secondary shield walls. This is different floor area from the above (2).

(4) Feedwater pipe (16in) break at steam generator nozzle
Secondary line break inside secondary shield walls was also examined. The break point was located at steam generator nozzle that locates upper area inside secondary shield walls.

2. Zone of influence

The "zone of influence" for each insulation type used for debris generation calculations due to MCP breaks was discussed in the section 3.1 and Table 3-2 in the technical report MUAP-08001. The energy of secondary lines are lower than that of MCP (reactor coolant system), smaller ZOIs due to secondary line break could be applied. However, in this evaluation, same ZOIs of MCP were conservatively used for debris generation calculations for secondary lines break.

Extract from MUAP-08001(R2) Table 3-2

Type	Destruction pressure (psig)	ZOI Radius / Break Diameter
RMI	114.0	2.0
Fibrous insulation	6.0	17.0

3. Result

The result of comparable calculation for four limiting break locations versus MCP break is summarized in the following table. It demonstrated that MCP break is the worst case of debris generation for postulated accidents of the US-APWR.

Break pipe	Debris type and amount		
	RMI	Fibrous	Coating
Pressurizer surge pipe (16in)	0.21 m^3 [7 ft^3]	0.79m^3 [28 ft^3]	0.09 m^3 [3 ft^3]
MS pipe (31in) (outside secondary shield wall)	0.63 m^3 [22 ft^3]	0.90 m^3 [32 ft^3]	0.45 m^3 [16 ft^3]
FW pipe (16in) (outside secondary shield wall)	0.3 m^3 [11 ft^3]	0.35 m^3 [12 ft^3]	0.11 m^3 [4 ft^3]
FW pipe(16 in) (inside secondary shield wall)	0.27 m^3 [10 ft^3]	0.12 m^3 [4 ft^3]	0.11 m^3 [4 ft^3]
MCP (design basis)	3.0 m^3 [106 ft^3]	1.3 m^3 [46 ft^3]	0.51 m^3 [18 ft^3]

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-21

The NRC staff requests that MHI provide the following information regarding debris characteristics. MUAP-08001 Section 3.3 considers all generated debris to be "small". Define the size classification term "small" and provide the reference for this classification.

ANSWER:

Refer the response to Question 06.02.02-22 combining our answer to Question 06.02.02-21 for debris characteristics with respect to debris transportation and resultant the head loss.

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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07/07/2009

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APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-22

For PWR analyses, it is important to distinguish between suspended and non-suspended debris. What does APWR imply when it states debris is "small" in regards to suspended or non-suspended debris? Does "small" indicate that all the material is in suspension? Provide technical basis and justify why this is conservative with respect to transport and head loss.

ANSWER:

MHI agrees that section 3.3 of MAUP-08001 does not define the term "small" and does not provide the basis for this classification. Data provided in Table 3.5 is the size of fibrous material and coating particles. MHI agrees to provide data defining the term "small" and the basis for that classification in regard to transport and head loss. The section 3.3 of MAUP-08001 will be revised with additional information as discussed below.

The term "small" is used for fibrous insulation debris and refers to "fines" and "smalls" discussed in NEI 04-07 (GR). There is no further basis that explicitly defines any fibrous debris size characterization and associated debris size characterization distribution in the guidance.

The NEI GR classified fibrous debris into 4 groups as follows:

1. fines that remain suspended
2. small piece debris that are transported along the floor
3. large piece debris with the insulation exposed to potential erosion
4. large debris with the insulation undamaged and/or still protected by a covering and thereby preventing erosion

Therefore, fines of fiber debris are considered as suspended, and smalls are considered as non-suspended, but subject to transport along the floor.

The NEI GR for debris transporting to the sump strainer states that 60% of the fibers generated (classified as "smalls / fines") will transport and 40% of fibers generated (classified as "large") do not transport. Since the US-APWR considered all fibrous debris is smalls/fines and reachable to the RWSP, this assumption is more conservative than approved guidance in terms of transport and head loss.

As for reflective material insulation (RMI) debris, the US-APWR applies the NEI GR that 75 percent for small fines and 25 percent for large pieces as the size distribution of RMI debris. These values are based on the size distribution of less than 4 inches as listed in Figure 3-7 of NUREG/CR-6808. The RMI debris is considered as "non-suspended" in the sump pool due to its specific gravity.

As for coating debris, the NEI GR considers that all coating within the coatings ZOI is to fail when subject to DBA conditions. Absent applicable experimental data, a coating debris size value of 100 percent small fines is adopted by the GR for all types of coating material in the ZOI. Therefore, the US-APWR considers that all of coating debris is small fines discussed in the GR, and will be suspended in the sump pool.

For latent debris, its characteristics were based on safety evaluation report (SE) for NEI GR. The latent fiber is comparable to fiberglass (Nukon) insulation, and considered as "fine". Latent particles are the latent dust and dirt debris mixture, and the size distribution of them is based on the guidance found in NUREG/ CR-6877.

The size characteristics of debris were determined based on approved guidance as discussed in the above. Regardless its specific gravity, suspended or non-suspended, all of debris were considered reachable to the RWSP in the transport evaluation as discussed in section 3.3 of MUAP-08001(R2). This assumption was conservative with respect to transport and head loss.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

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SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-23

MUAP 08001-NP (R2) discusses how LOCA generated debris is transported to the sump. LOCA generated debris is initially distributed over the floor of the four steam generator compartments (inside secondary shield). Then, debris laden water overflows a 2 inch high slope located at four labyrinth access openings to exit the steam generator compartments and enter the containment floor area (outside the secondary shield). On the containment floor, the debris is routed to the RWSP at five (5) locations via pairs of drain pipes. The debris is assumed to be equivalently allocated (20%) to each of the five drain pipe locations. Justify assumption of equivalent allocation (20%) of debris to the 5 drain pipe locations? Demonstrate how the 20% debris allocation pattern is conservative given the worst case break location occurring in A-Loop? In addition, MUAP 08001 assumes 100% transport to the RWSP and 100% transport to the two (50% capacity) operable strainers. The maximum debris allocation to any one strainer is assumed to be 70%. Justify how a 70% debris allocation assumption is conservative with respect to head loss and resultant impact on NPSH.

ANSWER:

Equivalent distribution (20%) to each of the five drain pipe location was an engineering assumption based on the credible debris transport behavior inside secondary shield walls as discussed in the report. This realistic assumption should not be justified to be conservative independently to other conservative assumptions with respect to head loss and resultant impact on NPSH. The validity of worst debris allocation pattern (i.e., 70% debris per one sump and 30% debris per another sump) shall be evaluated as an eventual design parameter ultimately impacts on the head loss. The conservative of 70/30 debris allocation for two sumps shall be demonstrated by comparing with independent evaluations including debris generation and transport using approved methodology NEI GR.

The conservativeness of the US-APWR in terms of debris generation and transport comparing with NEI GR is summarized as follows:

<u>Fibrous insulation debris:</u>

- All of fibrous insulation contained in one SG compartment was considered to be the debris as discussed in the technical report. The estimated debris (i.e., 46ft3, Refer Table 3-4 in

MUAP-08001) included the amount of insulation located outside ZOI in the compartment. This is more conservative than approved ZOI (zone of influence) methodology, NEI GR.

- All of fibrous insulation debris (i.e., 46ft3) is defined as "small" as discussed in the response to Question 06.02.02-22. This is more conservative than approved methodology for debris transporting to the sump that 60% of the fibers generated (classified as "smalls / fines") will transport and 40% of fibers generated (classified as "large") do not transport.

- All of generated fibrous insulation debris (i.e., 46ft3) was considered as reachable to the RWSP. Based on realistic assumption for debris transport behavior as discussed in the technical report, the worst case scenario of debris allocation for two of four operable train sumps was considered that; 70% (32.2ft3) debris is allocated to one sump, and 30% (13.8 ft3) debris is allocated to another sump. This was the design basis of fibrous insulation debris allocated to operable sumps of the US-APWR.

Meanwhile, independent evaluation using approved methodology NEI GR was performed as follows to demonstrate that the worst case debris allocation (70/30) is conservative with respect to the head loss:

- The generated debris (i.e., 46 ft3) is grouped into "small" and "large" debris for debris transporting to the sump that 60% (i.e., 27.6 ft3) of the fibers generated (classified as "smalls / fines") will transport and 40% of fibers generated (classified as "large") do not transport.

- Of the generated debris, 60% (i.e., 27.6 ft3) of small/fine debris was reachable debris to the RWSP. The reachable debris would be allocated to two of four operable sumps. The worst case of allocation to two sumps was considered that all of reachable debris (i.e., 27.6ft3) to the RWSP is allocated to one sump and another sump is clean, with respect to resultant impact on NPSH.

In the results, it is demonstrated that the design basis of debris allocation (i.e., 32.2 ft3) of fibrous insulation debris used for the US-APWR is more conservative than the independent evaluation result (i.e., 27.6 ft3) using approved methodology NEI GR.

RMI debris:

The technical report MUAP-08001 section 3.4 last paragraph provided discussions for transportability of RMI debris. It was concluded the RMI debris may not a problem to the strainer with respect to the head loss. Regardless, independent evaluation with respect to debris allocation to the sumps is provided as follows:

- The RMI installed on one main coolant pipe (i.e., 106 ft3, Refer Table 304 in MUAP-08001) which is maximum diameter pipe possible to break inside containment was considered to be debris. This is more conservative than approved ZOI methodology which recommends use of 2 inside diameters (2D) of ZOI for RMI.

- All of RMI debris (i.e., 106 ft3) was defined as "small (reachable)" as discussed in the response to Question 06.02.02-22. This is more conservative than approved methodology for debris transporting to the sump that 75% of the RMI debris generated (classified as "smalls") will transport and 25% of RMI debris generated (classified as "large") do not transport.

- All of generated RMI debris (i.e., 106 ft3) was considered as reachable to the RWSP. Based on realistic assumption for debris transport behavior as discussed, the worst case scenario of debris allocation for two of four operable train sumps was considered that; 70% (74.2 ft3) debris is allocated to one sump, and 30% (31.8 ft3) debris is allocated to another sump. This was the design basis of RMI debris allocated to operable sumps of the US-APWR.

Independent evaluation using approved methodology NEI GR was performed as follows to demonstrate that the worst case debris allocation (70/30) is conservative with respect to the head loss:

- The debris generation analysis was performed applying 2D of ZOI as independent evaluation. The worst case break location was the nozzle of steam generator connected to main coolant pipe (31' diameter) which would destruct RMI attached on MCP itself and SG within the ZOI. The RMI debris of independent evaluation was 50 ft3.

- The generated debris (i.e., 50 ft3) was grouped into "small" and "large" debris for debris transporting to the sump that 75% (i.e., 37.5 ft3) of RMI generated (classified as "small") will transport and 25% (i.e., 12.5 ft3)of RMI generated (classified as "large") do not transport.

- Of the generated debris, 75% (i.e., 37.5 ft3) of small debris was reachable debris to the RWSP. The reachable debris would be allocated to two of four operable sumps. The worst case of allocation to two sumps was considered that all of reachable debris (i.e., 37.5 ft3) to the RWSP is allocated to one sump and another sump is clean, with respect to resultant impact on NPSH.

In conclusion, the design basis of debris allocation (i.e., 74.2 ft3) of RMI insulation debris used for the US-APWR is more conservative than the independent evaluation result (i.e., 37.5 ft3) using approved methodology NEI GR.

Coating debris

As for coating debris, independent evaluation was not required for justification the design basis allocation to the sumps. Followings are additional discussions for justification the conservatism:

- The coating debris was calculated using 10D of ZOI. The amount of debris was calculated the surface area of ZOI sphere multiplying maximum dry film thickness of coating. (Refer the response to Question 06.02.02-16 in the RAI 248-2250 for justification and conservatism of the calculation.)

- All of coating debris was defined as small fines (reachable) as per the recommendation of NEI GR, as discussed in the response to Question 06.02.02-22. No additional conservatism than the NEI GR was considered in the debris size classification.

- The small fine coating debris will be suspended in the recirculation flow, and easily dispersed on the containment floor. The small fine particulate debris is readily be drained thru floor drains to the containment sump pit which was considered hold-up volume of the US-APWR. However, all of small fine coating debris was conservatively considered reachable to the RWSP in the evaluation.

- The small fine particle debris suspended in the RWSP will readily reach to the sump, but may pass though the strainer. The coating debris will be circulated in the emergency core cooling and containment spray systems, and dispersed over the containment. Then, the coating debris will gradually be allocated to the sumps, almost equivalently to each sump, after the fibrous debris bed formation on the strainer.

Therefore, the design basis of coating debris allocation to the sumps (i.e., 70/30) is conservative with respect to the strainer head loss.

Latent debris

The discussions for latent debris with respect to allocation to the sumps have already been provided in the technical report MUAP-08001 section 3.4 tenth paragraph. The latent debris potentially exists whole containment will be corrected from five transfer pipe locations, regardless pipe break locations. No further discussion may be required for justification the design basis allocation of latent debris (i.e., 70/30).

Chemical debris

The chemical debris is generated by chemical reaction by the sump fluid transient and resolved elements from corrosive materials existed in the containment. The chemical debris will be generated through long term recirculation, and therefore the debris will not be concentrated either of sumps due to the pipe break location. Therefore, the design basis chemical debris allocation (i.e., 70/30) is conservative with respect to the strainer head loss.

Miscellaneous debris

As discussed in seventh paragraph in MUAP-08001 (R2) section 3.2, a 200ft2 penalty of sacrificial strainer surface area per sump was considered, regardless the debris allocation pattern (i.e., 70/30) or pipe break location. This is most conservative assumption with respect to the strainer head loss.

MHI will revise MAUP-08001(R2) Section 3.7 to add above discussions to justify that the design basis debris allocation (i.e., 70% for one sump and 30% for remain) is conservative with respect to head loss and resultant impact on NPSH.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: NO. 354-2585 REVISION 0

SRP SECTION: 06.02.02 – Containment Heat Removal System

APPLICATION SECTION: 6.2.2 & 6.3

DATE OF RAI ISSUE: 05/07/2009

QUESTION NO.: 06.02.02-24

MUAP 08001-NP (R2) Section 3.7.1 states, "In the refueling cavity, there are two 8 inches drain pipes which are communicated to bottom portion of the containment...and it is quite unlikely that a large amount of fibrous debris will blow down on the cavity, and block the drain path." The NRC staff requests that MHI provide the following information regarding upstream effects associated with these two 8 inch drain pipes:

1) Please describe what "communicated to bottom portion of containment" means? Do they go directly to RWSP? Are these drains depicted in the DCD (for example, DCD Figure 6.2.1-9)?

2) If the drain pipes were to fully block flow, how much water holdup would occur and what would the impact be on cooling the core and cooling containment?

3) What amount of water holdup (expressed in gallons or cubic meters and height in refueling cavity as well as height in RWSP) would result in challenging head loss across strainer (submergence etc) and/or NPSHa?

4) Operating plants with similar drain configurations have installed debris interceptors to ensure the drains remain functional during an accident. What is the APWR justification for not establishing debris interceptors?

ANSWER:

1) The phrase, "communicated to bottom portion of containment", means that reactor cavity drain piping is connected directly to the RWSP. Refer the Figure 6.2.1-13 in the DCD.

2) If the refueling cavity drain pipes were to fully blocked, containment spray water dropped on there may not be drained from refueling cavity. In the result, safety pumps required for long term cooling may not be operated in safely because the RWSP minimum water level will be lowered than design basis.

3) The amount of water in the refueling cavity accounted for "in-effective pool (i.e., 70.7 m3)" was provided in Table 3-10 of the technical report MUAP-08001. In addition, 2 in height of water stream on the refueling cavity floor (i.e., 6.9m3) were included in "water stream on the floor"

(i.e., 185.0m3, See Table 3-10). No further additional hold up volume due to fully blockage of cavity drains was accounted in the upstream effect evaluation. Given the additional hold up volumes beyond the design basis, the RWSP water level will be lowered approximately 5.3 cm per each 100m3 of entrapped water.

4) MHI did not know other plant design basis for installation of debris interceptors on refueling cavity. It may be due to different design or other reasons. Regardless, following is additional justifications for not installing debris interceptor for refueling cavity drains.

- The US-APWR will be categorized as low-fiber plant. The amount of debris, as provided in the response to Question 06.02.02-19, may be relatively lower than operating plants.

- The US-APWR defines that all debris are "small" as discussed in the response to Question 06.02.02-21 and 06.02.02-22. There is no "large" debris which potentially blocks the cavity drains. In fact, given that pipe break inside secondary shield walls, layer of grating floors will filter "large" debris, and therefore, only "small" debris will be transported to upper portion of containment, then falls on the operating floor or refueling cavity.

- Given that pipe break outside secondary shield walls, two layers of grating above the operating floor which cover the insulated pipe lines will filter "large" debris as well. (See Figure 1.2-10 thru 1.2.12)

- As shown in DCD Figure 6.2.1-9, the hold-up volume "Upper core internal laydown pit" exists in the refueling cavity, and it may trap the debris on the refueling cavity and reduce the amount toward the cavity drain pipes.

- Given that one refueling cavity drain pipe being assumed "blocked", the remaining pipe is still capable to drain the retained water on the cavity floor. (Refer the response to Question 06.02.02-39.)

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

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SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-25

DCD Table 6.2.2-2 provides MHI's response to regulatory positions established by RG 1.82. Regulatory position 1.1.1.5 states that drains and other narrow pathways that connect compartments with potential break locations to the ECC sump should be designed to ensure that they would not become blocked by the debris; this is to ensure that water needed for adequate NPSH margin could not be held up or diverted from the sump. Besides the transfer pipes, and refueling cavity drains, provide a list other drains and narrow pathways (if any) and discuss how they are designed to ensure they are not blocked by debris.

ANSWER:

MHI agrees that the DCD Table 6.2.2-2 does not provide a list of "other drains and narrow pathways" to the RSWP or discussion of how such drains and narrow pathways are designed to ensure they are not blocked by debris.

Besides the transfer pipes and refueling cavity drains, no other drains or narrow pathways are assumed to provide make-up to the RWSP. Floor drain piping which collects in the containment sump, such as the SG compartment floor and the operating floor, is assumed to become blocked. Containment Spray water is drained to lower containment levels by way of stairway openings, equipment hatch, or compartment access openings. These openings are not considered to be narrow pathways vulnerable to blockage. Since the floor drains are assumed to be blocked, an amount of Containment Spray water is assumed to collect and remain on various Containment levels. The heights of the water remaining on the Containment floors are assumed to be 0.05 m (2 in) on the EL 76"-5" and EL 50'-2" floor and 0.15 m (6 in) on the EL 25'-3" floor. This amount of remaining water is factored into the return water hold-up volume in the calculation of refueling water storage pit (RWSP) water levels.

Impact on DCD

The DCD Table 6.2.2-2 Item Number 1.1.1.5, the column titled Table "US-APWR Design" will be revised to add following description after the last sentence:

"Besides the transfer pipes and refueling cavity drains, no other drains or narrow pathways are assumed to provide make-up to the RWSP. Floor drain piping which collects in the

Containment sump, such as the SG compartment floor and operating floor, is assumed to become blocked. Containment Spray water is drained to lower containment levels by way of stairway openings, equipment hatch, or compartment access openings. These openings are not considered to be narrow pathways vulnerable to blockage. Since the floor drains are assumed to be blocked, an amount of Containment Spray water is assumed to collect and remain on various Containment levels. The heights of the water remaining on the Containment floors are assumed to be 0.05 m (2 in) on the EL 76"-5"and EL 50'-2" floor and refueling cavity, and 0.15 m (6 in) on the EL 25'-3" floor. This amount of remaining water is factored into the return water hold-up volume in the calculation of refueling water storage pit (RWSP) water levels."

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-26

MUAP 08001-NP (R2) states that an adequate water level exists to submerge the strainer in case of a LBLOCA. The report further states, "The strainers are installed so as to submerge the top of the layer disk 3.67" under the minimum water level." The NRC staff requests that MHI provide the minimum submergence under small break loss of coolant accident conditions. Explain the difference between the small and large break strainer submergence level (if any) or the basis for no difference.

ANSWER:

The US-APWR has a different design to operating PWR plants that it does not need "switch over" to continue long term core cooling after postulated accident. The US-APWR has an in-containment water resource (i.e., the RWSP) for the postulated accident that is normally filled up by borated water. Therefore, the strainer of the US-APWR is fully submerged during normal operation. The initial water depth in the RWSP is 18'-4". In case of LBLOCA, a large volume of water will be lost from reactor coolant system and released into containment. To compensate the loss of water, the RWSP water is injected into reactor coolant system, then the RWSP water depth is getting lowered, and reaches to minimum water level (i.e., 4.0ft). In case of SBLOCA, less volume of water than that of LBLOCA will be lost from reactor coolant system, therefore, less water volume of the RWSP is consumed than that of LBLOCA. This means that LBLOCA is the worst case for the US-APWR to lead minimum water level for the strainer.

The calculation for minimum water level was provided in the subsection 3.7 in the technical report MUAP-08001(R2). The US-APWR does not concern the partial submergence of the strainer for any postulated accidents. The strainer of the APWR is always fully submerged, except for during plant shutdown.

MUAP-08001(R2) will be revised to provide the discussion for minimum submergence of the sump strainers under small break loss-of-coolant accident conditions as replied in the above.

Impact on DCD

There is no impact on the COLA

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-27

DCD Table 6.2.2-2 compares APWR design to the requirements of RG1.82 position 1.1.1.13 and states RWSP suction strainers are submerged under a minimum of approximately 4 ft. of water during a LOCA. MUAP 08001-NP (R2) states the strainers are installed so as to submerge the top of the layer disk 3.67" under the minimum water level (page 3). Please explain the difference in levels of submergence.

ANSWER:

MHI agrees that there is a difference in the discussion of levels of submergence of the RWSP suction strainers found in MUAP 08001 (R2) and the DCD Table 6.2.2-2. The discussion found in MUAP 08001 (R2) accurately reflects the RWSP suction strainer design. Additional text is needed to accurately describe the configuration of the minimum RWSP water level and the RWSP suction strainer submergence below the surface of the water in the RWSP. MHI will therefore revise the discussion in the DCD Table 6.2.2-2, item Number 1.1.1.13.

Impact on DCD

The DCD Table 6.2.2-2 item number 1.1.1.13 under the heading "US-APWR Design" will be changed to read as follows:

> "During a LOCA, the minimum depth of water in the RWSP is 4 feet. At that minimum depth, the top of each RWSP suction strainer is submerged 3.67" below the surface of the water in the RWSP. The RWSP recirculation supply is sufficient to preclude adverse hydraulic effects (e.g., vortex formation and high suction head loss). A low approach velocity at the strainer surface also mitigates the risk of vortexing."

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-28

MUAP 08001-NP (R2) Appendix A states the PCI strainer design discourages and prevents vortex formation and air ingestion. The NRC staff requests MHI justify that the APWR application of the PCI strainer design prevents vortex formation and air ingestion. Provide a summary of the methodology and assumptions of the vortexing evaluation and any bases for key assumptions. Describe significant margins and conservatisms used in the vortexing calculations.

ANSWER:

PCI Technical Document No. SFSS-TD-2007-003, Sure-Flow® Suction Strainer Vortex Issues provides a summary of the methodology and assumptions utilized in the design and technical application of the PCI technology as it relates to the issues of vortex formation and potential subsequent air ingestion. PCI Technical Document No. SFSS-TD-2007-003 was previously submitted to the NRC in support of GL 2004-02 Licensee responses. PCI submitted the subject document as a "proprietary & confidential" document in accordance with 10 CFR Part 2.390.

The subject methodology described in PCI Technical Document No. SFSS-TD-2007-003 is utilized as the basis for calculation TDI-6034-07, Vortex, Air Ingestion & Void Fraction, US-APWR. The subject calculation provides the specific methodology, basis, and assumptions for evaluating the US-APWR with regard to the issues of vortex and air ingestion. The calculations are in process for completion, but its preliminary results based on the US-APWR maximum allowable head loss for the ECCS strainer of 4.7 feet of water indicate that there are no issues with regard to vortex formation and air ingestion.

The PCI Sure-Flow® Suction Strainer technology has been extensively tested with regard to the issues of vortex formation and air ingestion. Testing has been performed by PCI and independently at the Fairbanks-Morse Pump Company (FMPC), the Alden Research Laboratory (ARL), and the Electric Power Research Institute's (EPRI) Charlotte NDE Center. The subject testing has been performed on both a generic and Licensee specific basis for both pressurized water reactor (PWR) and boiling water reactor (BWR) nuclear power plants in vertical and horizontal strainer orientation configurations as well partially (i.e., small break LOCA (SBLOCA) and flood-up/rising water scenarios) and fully submerged post-LOCA conditions. In no case has sustained vortex formation been observed during the multitude of strainer tests that would result in subsequent air ingestion.

The PCI Sure-Flow® Suction Strainer has a unique and patented suction flow control device (SFCD) integral to the strainer. It is known as the core tube. The primary function of the SFCD technology is to provide uniform flow to the entire Sure-Flow® Suction Strainer which directly results in overall decreased head loss and the prevention of vortex formation. The design of the SFCD is one of a series of defense-in-depth vortex suppressor design features (i.e., various redundant vortex suppression devices - combination of perforated plate, parallel disk plates, disk wire "grills", and the module external structural bracing) to assure that vortex formation does not occur and subsequently air is not ingested. The SFCD technology is described in PCI Technical Document Number SSFS-TD-2007-002, Suction Flow Control Device (SFCD) Principles and Clean Strainer Head Loss Design Procedures. PCI Technical Document Number SSFS-TD-2007-002 was previously submitted to the Staff in support of GL 2004-02 Licensee responses. PCI submitted the subject document as a "proprietary & confidential" document in accordance with 10 CFR Part 2.390.

In order to mitigate or suppress a vortex, different measures can be taken. One of the most efficient ways is to ensure that the water head above the pump inlet is greater than the critical submergence head. However, this situation may not be possible, since in many cases the head may be affected by the strainer debris loading/head loss, is not constant, and can vary during the operation of the pump over its design basis conditions. This is the specific case associated with the operation of the US-APWR ECCS and CS pumps post-LOCA following initiation of recirculation. Therefore, other means or combinations thereof to avoid or reduce free vortex flows are required. There are three (3) possible means or categories that can eliminate and suppress surface vortices. They are as follows:

1. Elongation of fluid flow streamlines between the pump inlet and the free water surface,

2. Elimination of approach flow velocity non-uniformity (i.e., uniform approach velocity), and

3. Use of special vortex suppression device(s)

The regulatory requirements, actually guidance with regard to the specific issue of vortex formation and the related issue of air ingestion are addressed in various sections of RG 1.82, Revision 3.

In RG 1.82, Revision 3, specifically Table A-6 guidance is provided with regard to vortex suppression. The subject table specifies that standard 1.5" or deeper floor grating (e.g., 4" x 4" opening) or its equivalent has the capability to suppress the formation of a vortex with at least 6" of submergence. The NRC carried out a number of tests regarding vortex suppressors at the Alden Research Laboratory (ARL) to arrive at the information summarized in Table A-6. Table A-6 is based upon the significant testing and evaluation that was performed by ARL under contract to the USNRC with respect to the issue of ECCS sump performance, vortex formation, and vortex suppression. The activities performed by ARL are documented in USNRC NUREG/CR-2772 and -2761 and are supported by the NRC NUREG/CR-2758, -2759, and -2760.

Even though the subject NUREG/CRs dealt specifically with the issue of vortex formation and suppression in an ECCS sump, the conclusions are also relevant to the PCI Sure-Flow® Suction Strainer for the US-APWR. The perforated plate that surrounds 100% of the PCI Sure-Flow® Suction Strainer core tube is equivalent to (actually exceeds) the floor grating recommended and specified in RG 1.82 Revision 3 and NUREG/CR-2772 and -2761, and therefore has the capability to completely suppress the formation of a vortex and preclude subsequent air ingestion.

In addition, RG 1.82, Revision 3 provides further guidance with respect to air ingestion in Table A-6 and specific guidelines for selected vortex suppressors. The guidance is divided into two (2) categories; (1) cubic and non-cubic suppressors surrounding the pump inlet within the sump, and (2) horizontally oriented grating covering the entire sump. It should be noted that the subject

Table has the following NOTE: Tests of these types of vortex suppressors at Alden Research Laboratory have demonstrated their capability to reduce air ingestion to zero even under the most adverse conditions simulated (emphasis added).

Even though the PCI Sure-Flow® Suction Strainers do not employ the specific use of grating in their design, they do utilize a combination of perforated plates, parallel disk plates, disk wire "grills", module external structural bracing, and the resultant tortuous strainer internal flow path that is more than equal to the singular vortex prevention capabilities of the grating. Furthermore, the PCI Sure-Flow® Suction Strainers satisfy not one, but both guidance categories as delineated in RG 1.82, Revision 3, specifically Table A-6.

The PCI Sure-Flow® Suction Strainer assembly for PWRs is comprised of either vertically or horizontally oriented strainer modules each containing a plant specific number of strainer module disks. The disks are a nominal 5/8" thick (i.e., nominal ½" internal thickness) and are separated 1" from each adjacent disk. The interior of the disks contain rectangular wire stiffeners for support, configured as a "sandwich" made up of three (3) layers of wires - 7 gauge, 8 gauge, and 7 gauge, respectively. The disks are completely covered with perforated plate having plant specific sized holes. The end disk of a module is separated approximately 5" from the end disk of an adjacent module. The 5" space between adjacent modules is covered with a solid sheet metal "collar" to seal the module-to-module separation opening. Each of the modules has plant specific structural cross-bracing on the exterior surfaces of each module.

Based on the design configuration of the PCI Sure-Flow® Suction Strainer assembly, the largest opening for water to enter into the sump is through the perforated plate holes. The size of the perforated plate holes by themselves would preclude the formation of a vortex. In the case of all the PCI Sure-Flow® Suction Strainer designs, the largest perforated plate hole opening is only 0.095", which is only 75% of the 0.125" hole openings that were tested by ARL for the USNRC as documented in NUREG/CR-2772 and -2761. It should also be noted that the strainer perforated plate hole openings are significantly smaller than the large openings associated with the recommend grating (i.e., 1.5" thick x 4" x 4") vortex suppressor design as recommended and specified in RG 1.82 Revision 3 and NUREG/CR-2772 and -2761.

However, in the highly unlikely event that a series of "mini-vortices" combined in the interior of a disk to form a vortex, the combination of the wire stiffener "sandwich", the physical closeness of the disk perforated plates (i.e., nominal ½" internal thickness), and the small openings and passages that direct (i.e., tortuous path) the flow of water to the strainer core tube would further preclude the formation of a vortex in either the core tube or the sump.

With regard to category (1) cubic and non-cubic suppressors, the PCI suction strainer design "surrounds" the core tube (i.e., cubic suppressor) with a combination of perforated plate, parallel disk plates, internal disk wire "grills", and module external structural bracing. This results in not one, but four separate vortex suppressing devices that would prevent both external and internal vortex formation and potential re-formation.

In addition, the PCI Sure-Flow® Suction Strainer assemblies as designed and installed completely cover the existing PWR sump (i.e., ECCS and CS pump inlets). Therefore, the strainer assembly could also be considered to be a non-cubic suppressor as well.

Finally, since the strainer assembly covers the entire sump, it can be concluded and as previously discussed, the PCI Sure-Flow® Suction Strainer assembly configuration is more than equal to the vortex prevention capabilities of a single 'layer' of horizontally oriented grating due to its "defense-in-depth" multiple vortex suppressors. This is based on the physical configuration of the PCI Sure-Flow® Suction Strainer assembly which incorporates a combination of perforated plate, parallel disk plates, internal disk wire "grills", and module external structural bracing that results in both the tortuous strainer fluid flow path (i.e., the strainer module core tubes with staggered holes would offer even a more torturous flow path and resistance to circulation, making a coherent core vortex including air-drawing vortices unsustainable.), and significant extension of the fluid streamlines (i.e., free water surface to pump inlet) due to the convoluted extended external and internal strainer surface area.

In conclusion, the PCI Sure-Flow® Strainer design incorporates all three (3) recognized and recommended means for vortex elimination and suppression:

1. Long flow path from water surface through the PCI Sure-Flow® Strainer, plenum, sump, and ECCS pump inlet piping,

2. PCI Sure-Flow® Strainer suction flow control device (SFCD) technology – the 'core tube' provides uniform approach velocity to all strainer modules, and

3. PCI Sure-Flow® Strainer design utilizes a combination of recognized 'defense in depth' multiple vortex suppression devices – perforated plate, parallel disk plates, disk grill wires, core tube slots, module external bracing, and the resultant tortuous strainer internal flow path – all providing more than the single grating vortex suppressor recommended in RG 1.82 Revision 3.

Based on the above discussion and supporting references, there is considerable and reasonable test, analytical and empirical data that demonstrates that the US-APWR Sure-Flow® Suction Strainer will not promote or support vortex formation, but will in fact suppress the formation of a vortex. Accordingly, air ingestion is also precluded, since there is no mechanism to draw air into the ECCS and CS pumps' suction.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-29

In MUAP 08001-NP (R2) Section 3.1, Break Selection, page 9, states, "For the USAPWR, PCI SFS has been selected. PCI has never observed any evidence of the thin bed effect in vendor's large flume testing facilities in the past, because of its three dimensional geometry and very low approach velocities. The TBE may occur only under such very controlled conditions where the fibrous debris is very carefully prepared as individual fibers that are slowly added to a closed vertical pipe loop test apparatus. This configuration is not applicable for the US-APWR strainer design and configuration in the RWSP of the post-LOCA conditions." This statement appears to be in conflict with recent operating plant testing experience during which high head loss (>20 feet) was achieved – indicative of a thin-bed effect - using a similarly designed PCI strainer. Therefore, the NRC staff requests MHI to address the ability of the screen to resist the formation of a thin bed or to accommodate partial thin bed formation.

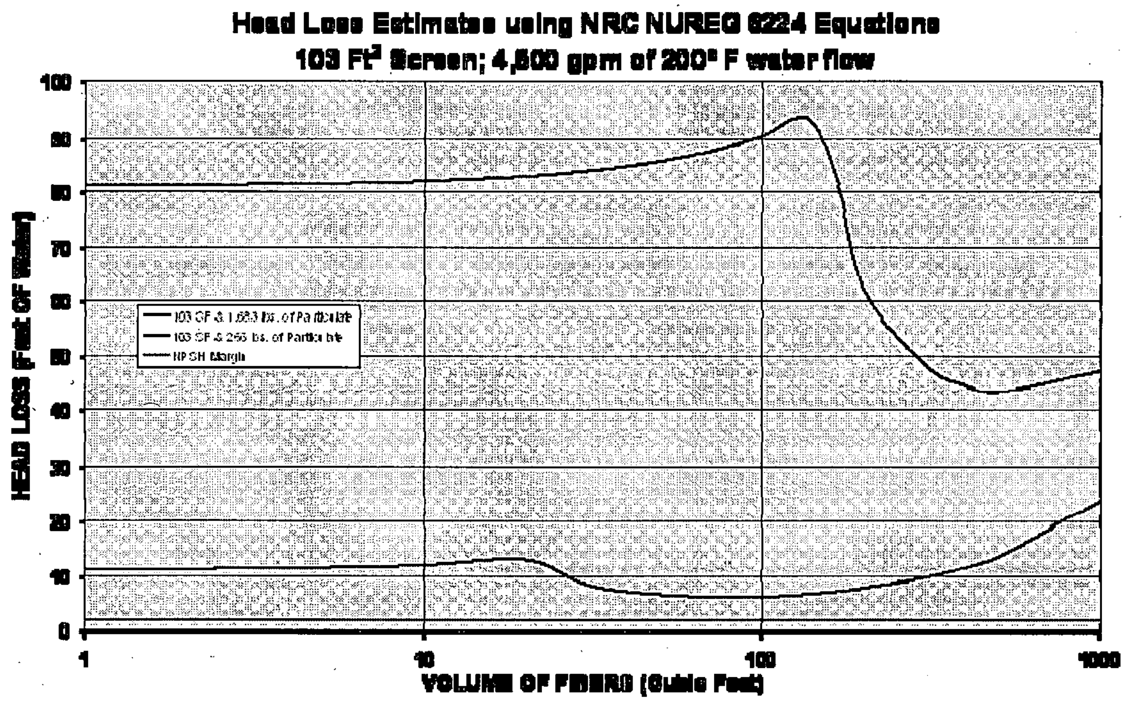
ANSWER:

The other plant case cited by the NRC is a high fiber design basis capable of engulfing the strainer if all fibrous debris predicted to reach the strainer actually did reach the screen in the test.

The statement, "PCI has never observed any evidence of the thin bed effect in vendor's large flume testing facilities in the past, because of its three dimensional geometry and very low approach velocities." is not saying their strainers have not formed a thin bed in a single test; nor is stating that high head losses do not occur from thin mixed fibrous / particulate debris beds on PCI strainers. The intention of the statement is that they have not observed the traditional NUREG CR/6224 head loss curve which plots the maximum head loss for different fiber debris quantities with a fixed quantity of particulates during *a single test.*

For example, in the NUREG CR/6224 curves plotted below, the curve is formed by plotting the highest head loss measured from many tests (or calculations using the NRC head loss calculator) with a fixed quantity of particulates but with many different fiber quantities. It is not the head loss curve of a single test.

Therefore, what PCI was saying is that they have not observed in a single test a rising head loss in the thin bed regime and then a falling head loss as more fiber is introduced into the large flume and /or collected on the strainer. In other words, PCI has not observed the head loss decreases when the fiber quantity introduced over some period of time exceeds the thin bed regime; as indicated by the NUREG CR/6224 curve below. There are some who believe these phenomena would be observed in a single test as "more and more fibers" are introduced to the test flume. However, PCI has not observed these phenomena.



In fact, thin beds is the ONLY type of debris bed PCI has observed to form with debris tests in the large flume; and usually only if the client has a high fiber design basis. The belief by the NRC that the NEI 04-07 transport methodology accurately predicts the quantity of fibers that will reach the strainers is grossly conservative based on those designs we have tested. A very high percentage of fibers do not transport in bounding, conservative flow streams. High fiber plants can form and may form a thin bed in some cases; low fiber plants generally leave open screen areas and therefore have low head losses. The US-APWR is a low fiber plant; which is why we do not expect a thin bed to form over all screen sections in our test.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: NO. 354-2585 REVISION 0

SRP SECTION: 06.02.02 – Containment Heat Removal System

APPLICATION SECTION: 6.2.2 & 6.3

DATE OF RAI ISSUE: 05/07/2009

QUESTION NO.: 06.02.02-30

DCD Table 6.3-5 (sheet 3 of 3) lists the RWSP peak temperature at approximately 250°F. DCD Figure 3.8.1-11 lists the RWSP peak temperature at 270°F. The NRC staff requests MHI explain why two peak temperatures are listed and provide a summary of the methodology, assumptions, and results used to determine if flashing would occur across the strainer surface. State the basis for peak temperature used in the flashing analysis. State whether containment accident pressure was credited and the methodology used to determine available containment pressure.

ANSWER:

The question 06.02.02-30 requested information for; a) inconsistency of the RWSP peak temperature in the DCD, and b) credible containment accident pressure used in the flashing analysis of the strainer. The answer is provided respectively as follows:

a) The envelope line of the RWSP water temperature listed in the DCD Figure 3.8.1-11 contains a total 20 °F margin to the calculated transients for various loss-of-coolant accidents (LOCAs). One item of the margin, 15 °F is the same as what is required to be assumed in the vapor temperature in the IEEE Std. 323 -1974 (Reference 1). It is employed with an intention of the component design basis being corresponding to that of the structural design. In addition, the envelope line includes another margin with uncertainty according to (1) expected design progress of the plant (2) possibility of modifying the mass and energy release evaluation methodology (MEREM) in LOCA (Reference 1) and (3) particularly analytical feature for evaluating RWSP water temperature high. Integrated margin of these uncertain items was estimated as approximately 5 °F. These assumptions are determined at early design control phase based on MHI's design experience and standard.

   By the approval of the MEREM in LOCA and design progress, MHI will perform the RWSP water temperature evaluation by using the approved MEREM in LOCA and the maximum containment analysis evaluation methodology. Some features to estimate the RWSP water temperature high will be employed in the maximum containment analysis methodology. The DCD Figure 3.8.1-11 will be replaced as the results of the re-analysis. The margin will be omitted in order to avoid confusion.

Reference

1. IEEE Std. 323-1974
2. MUAP-07012 Revision 2, P and NP "LOCA Mass and Energy Release Analysis Code Applicability Report for US-APWR", May 2008

b) PCI Technical Document No. TDI-6034-07, Vortex, Air Ingestion & Void Fraction, US-APWR provides the basis for addressing flashing across the strainer surface. The document provides the specific methodology, basis, and assumptions for evaluating the US-APWR with regard to the subject issue. The document is in the process of completing this calculation.

Preliminary results based on the US-APWR maximum allowable head loss for the ECCS strainer of 4.7 feet of water indicate that there are no issues with regard to flashing across the strainer surface. Accordingly, post-LOCA containment over-pressure is not required and credit for it is also not required.

In accordance with the guidance provided in the NRC Safety Guide 1.1 (Regulatory Guide 1.10) which has not changed since it was issued in 1970, paraphrased in part, that for ECCS NPSH evaluations, the post-LOCA containment initial conditions must be exactly the same as the pre-LOCA conditions for evaluating NPSH. In other words, immediately before the initiation of a LOCA, the pressure and temperature in the containment are at "normal" operating conditions - usually atmospheric pressure and the associated "normal" operating temperature. Accordingly, it is very conservatively assumed that the RWSP peak temperature is 250°F (given value as replied in the above a).) and atmospheric pressure was utilized to evaluate the US-APWR strainer for "flashing".

Based on the stated assumptions, this would result in a very conservative analysis. It is also recognized that the issue of post-LOCA containment "over-pressure" (i.e., containment accident pressure) was solely for NPSH calculations and the issue of strainer blockage (i.e., RG 1.82 Rev. 3, GSI-191, and GL-2004-02) was at the time never addressed as it related to the application of the "over-pressure" credit.

The NRC safety evaluation report (SER) provided in Volume 2 of NEI 04-07 indicates that ECCS pumps can experience cavitation problems when inlet void fraction exceeds approximately 3%. Since it is very difficult (if not impossible) to calculate the actual percentage of void fraction due to the many variables and dynamics of the post-LOCA strainer debris bed, a solution that completely eliminates void fraction was chosen.

There are two (2) possible methods to address void fraction. The first is to assess the static head of water based on the post-LOCA containment minimum water level. The static water head based on the height of the post-LOCA minimum containment water level to the centerline of the ECCS pump suction inlet must be determined. If the static water head height exceeds the calculated head loss across the strainer debris bed, then the static water head will have 'collapsed' any voids before they leave the containment (sump). In many cases this is the most straightforward and simple method of assessing void fraction issues. However, if the static water head height does not exceed the calculated head loss across the strainer bed, then void fraction is present. In this case, post-LOCA containment over-pressure credit is needed in order to eliminate the issue of void fraction. The issues of the NRC Safety Guide 1.1 requirements and GSI-191 with regard to credit of post-LOCA containment over-pressure was recently addressed by the Advisory Committee on Reactor Safeguards (ACRS) letter of March 18, 2009, titled, Crediting Containment Overpressure in Meeting the Net Positive Suction Head Required to Demonstrate that the Safety Systems Can Mitigate the Accidents As Designed (Accession No: ML090700464).

Based on preliminary results for calculation TDI-6034-07, Vortex, Air Ingestion & Void Fraction, US-APWR void fraction is not an issue. The static water head above the ECCS pump inlet lines within the sump exceeds the "worse-case" strainer total head loss. Accordingly, any voids will have collapsed before they enter the ECCS pump inlet lines. The conclusion is based on the following:

The US-APWR minimum post-LOCA water level is Elevation 7'-7". The centerline elevation of the ECCS pump suction line within the sump is approximately at Elevation 1'-10". This results in a static water head height of 5'-9". The maximum allowable head loss for the US-APWR strainer is 4.7' or 4'-8-3/16" at 70oF (it would actually be considerably less at the Design Basis temperature of 250oF). Since the static water head height of 5'-9" > 4.7', there will be no void fraction associated with the US-APWR at the maximum allowable head loss of 4.7'.

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-31

Consistent with guidance listed in RG 1.82 and GL 2004-02, provide a description of how permanent and temporary modifications to structures, systems, and components inside containment are programmatically controlled so changes to the analytical inputs and assumptions of the licensee analyses ensures ECCS remains in compliance with 10 CFR 50.46 and related regulatory requirements.

ANSWER:

Design change control procedures, procedures for conduct of maintenance activities, and administrative procedures for implementation of a cleanliness, housekeeping and foreign materials exclusion program will be established consistent with guidance provided in Regulatory Guide (RG) 1.82, Revision 3 and Generic Letter (GL) 2004-02 to ensure that potential quantities of post-accident debris are maintained within the bounds of the analyses and design bases that support Emergency Core Cooling (ECC) and Containment Spray (CS) recirculation functions and ensure the long term core cooling requirements of 10 CFR 50.46 will be accomplished.

Procedures will be implemented to ensure administrative controls and regulatory/quality requirements for plant modifications and temporary changes that include consideration of materials introduced into the containment that could contribute to sump strainer blockage. Included will be requirements for controlling temporary modifications to systems, structures and components (SSCs) in a manner which ensures compliance with 10 CFR 50.46. Future plant modifications will be evaluated in accordance with the requirements of 10 CFR 50.59 and 10 CFR 52.63.

The administrative controls will consider as a minimum, the introduction of additional sources of debris or modifications that could impact sump strainer performance including insulation, coatings, inactive volumes and structural changes (i.e., choke points).

The conduct of maintenance activities including associated temporary alterations is addressed in response to Question No. 06.02.02-32.

The cleanliness, housekeeping and foreign materials exclusion program for inside containment is addressed in response to Question No. 06.02.02-33.

In addition, ITAAC have been provided in DCD Tier 1 Table 2.4.4-5, *Emergency Core Cooling System Inspections, Tests, Analyses, and Acceptance Criteria*, to address the debris source term associated with insulation and coatings in containment. These ITAAC will verify consistency between the as-built insulation and coatings, and the evaluations described in MUAP-08001, US-APWR Sump Strainer Performance. (Refer to RAI 348-2587, Question No. 14.03.11-39).

DCD Subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5) will be revised to include additional COL Applicant responsibilities for the control of potential sources of post-accident debris inside containment. The DCD COL Item has been expanded to include the following:

- Control of permanent plant modifications to structures, systems, and components inside containment to include consideration of materials introduced inside containment.
- Conduct of maintenance activities, including associated temporary changes, subject to the provisions of 10 CFR 50.65(a)(4) that could contribute to sump strainer blockage (Refer to Question No. 06.02.02-32).
- Control on the amount of latent and miscellaneous debris introduced into containment as part of the cleanliness, housekeeping and foreign materials exclusion program (Refer to Question Nos. 06.02.02-35 and 06.02.02-36).
- Implementation of a containment coating monitoring program in accordance with the requirements of Regulatory Guide 1.54, Revision 1 (Refer to Question No. 06.02.02-34).

These additional programmatic controls will ensure that quantities of debris inside containment are maintained within the bounds of the analyses and design bases that support Emergency Core Cooling (ECC) and Containment Spray (CS) recirculation functions

Impact on DCD

DCD Tier 2 subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5), Table 1.8-2, COL Item 6.2(5) (Sheet 21 of 44), and Table 1.9.1-1 (Sheet 4 of 15) will be revised as follows:

Revise DCD Subsection 6.2.2.3 to state:

> ~~Preparation of a cleanliness, housekeeping and foreign materials exclusion program is the responsibility of the COL Applicant. This program addresses other debris sources such as latent debris inside containment. This program minimizes foreign materials in the containment.~~ **"Programmatic controls will be established by the COL Applicant to ensure potential sources of debris introduced into containment (e.g., insulation, coatings, foreign material), and plant modifications will not adversely impact the ECC/CS recirculation function. Programmatic control will be established consistent with guidance provided in RG 1.82, Rev. 3 to ensure that potential quantities of post-accident debris are maintained within the bounds of the analyses and design bases that support Emergency Core Cooling (ECC) and Containment Spray (CS) recirculation functions and ensure the long term core cooling requirements of 10 CFR 50.46 are met. The following is a summary of the programmatic controls that will be implemented to ensure that activities are conducted in a manner that ensures ECC/CS strainer operation, and limits the quantity of latent (unintended dirt, dust, paint chips, and fibers) and miscellaneous (tape, tags, stickers) debris inside containment:**
>
> - **Preparation of a cleanliness, housekeeping and foreign materials exclusion program. This program addresses latent and miscellaneous debris inside**

containment. An acceptance criterion below the conservative assumption of 200 lb for latent debris inside containment will be established consistent with MUAP-08001-P, Sump Strainer Performance Evaluation (Ref. 6.2-34). The program will also ensure that the quantity of miscellaneous debris will be limited such that the 200 ft^2 strainer surface area per sump uncertainty per MUAP-08001-P will be met to ensure ECC/CS strainer operation.

- **Control of permanent plant modifications to structures, systems, and components inside containment.**

- **Conduct of maintenance activities, including associated temporary changes, subject to the provisions of 10 CFR 50.65(a)(4).**

- **Containment coating monitoring program in accordance with the requirements of Regulatory Guide 1.54, Revision 1."**

Revise DCD Subsection 6.2.8, COL Item 6.2(5) to state:

COL 6.2(5) ~~Preparation of a cleanliness, housekeeping and foreign materials exclusion program is the responsibility of the COL applicant. This program addresses other debris sources such as latent debris inside containment. This program minimizes foreign materials in the containment.~~ ***"Programmatic controls will be established by the COL Applicant to ensure potential sources of debris introduced into containment (e.g., insulation, coatings, foreign material), and plant modifications will not adversely impact the ECC/CS recirculation function. Programmatic control will be established consistent with Subsection 6.2.2.3 to address the following areas:***

- ***Preparation of a cleanliness, housekeeping and foreign materials exclusion program.***
- ***Control of permanent plant modifications to structures, systems, and components inside containment.***
- ***Conduct of maintenance activities, including associated temporary changes, subject to the provisions of 10 CFR 50.65(a)(4).***
- ***Containment coating monitoring program in accordance with the requirements of Regulatory Guide 1.54, Revision 1."***

Revise Table 1.8-2, COL Item 6.2(5) (Sheet 21 of 44) to state:

~~Preparation of a cleanliness, housekeeping and foreign materials exclusion program is the responsibility of the COL applicant. This program addresses other debris sources such as latent debris inside containment. This program minimizes foreign materials in the containment.~~ ***"Programmatic controls will be established by the COL Applicant to ensure potential sources of debris introduced into containment (e.g., insulation, coatings, foreign material), and plant modifications will not adversely impact the ECC/CS recirculation function. Programmatic control will be established consistent with Subsection 6.2.2.3 to address the following areas:***

- ***Preparation of a cleanliness, housekeeping and foreign materials exclusion program.***
- ***Control of permanent plant modifications to structures, systems, and components inside containment.***
- ***Conduct of maintenance activities, including associated temporary changes, subject to the provisions of 10 CFR 50.65(a)(4).***
- ***Containment coating monitoring program in accordance with the requirements of Regulatory Guide 1.54, Revision 1."***

Revise Table 1.9.1-1 (Sheet 4 of 15) to add corresponding subsection 6.2.2.3 as a reference for RG 1.54.

Impact on COLA

The COLA shall be updated to address changes to the DCD for COL item 6.2(5).

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-32

Regarding programmatic controls taken to limit debris sources in containment, provide a description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.

ANSWER:

Combined License Applicant Item COL 17.6(1) addresses development and implementation of the maintenance rule program in accordance with 10 CFR 50.65. Maintenance activities, including associated temporary changes, will be subject to the provisions of 10 CFR 50.65(a)(4), which requires a licensee to assess and manage the increase in risk that may result from the proposed maintenance activities, prior to performing the activities. These activities may be shown to be acceptable with respect to the ECC/CS strainers by any of the following means:

1. performing the activities when the ECC/CS strainers are not required to be operable and restoring conditions consistent with the design bases prior to re-establishing operability;
2. deterministic evaluation that concludes the specific activities do not create a condition that adversely affects strainer performance;
3. control of maintenance activities within the bounds established by approved programs that assure no adverse impact (e.g., activities do not result in exceeding limits established for temporary use of material inside containment);
4. risk assessment for a specific activity.

As discussed in response to RAI 06.02.02-31, design change control procedures, procedures for conduct of maintenance activities, and administrative procedures for implementation of a cleanliness, housekeeping and foreign materials exclusion program for inside containment will be established consistent with guidance provided in RG 1.82 and GL 2004-02. These processes will ensure that potential quantities of post-accident debris are maintained within the bounds of the analyses and design bases that support Emergency Core Cooling (ECC) and Containment Spray (CS) recirculation functions and ensure the long term core cooling requirements of 10 CFR 50.46 will be accomplished.

Impact on DCD

DCD Tier 2 subsections 6.2.2.3 and 6.2.8 will be revised to require the COL Applicant to establish procedures for the conduct of maintenance activities including temporary changes to limit debris sources inside containment. Refer to the response to Question 06.02.02-31.

Impact on COLA

See the response to Question RAI 06.02.02-31 for the impact on COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-33

Regarding programmatic controls taken to limit debris sources in containment provide a summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.

ANSWER:

As discussed in DCD Subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5), the COL applicant is responsible for implementation of a cleanliness, housekeeping and foreign materials exclusion program for inside containment. Procedures to remove foreign materials and minimize the amount of debris that might be left in containment following refueling and maintenance outages will address the following:

- Frequency of cleanliness control and inspection activities for operation and maintenance
- Restriction of materials introduced into the containment
- Accounting for materials introduced into and out of the containment (e.g.,scaffold, tape, labels, plastic film, paper, cloth, keys, and pens)
- Cleaning of maintenance outage areas, including areas associated with removal or replacement of insulation
- Cleanliness inspections and removal of debris/foreign material, including operation and maintenance areas, RWSP, debris interceptors, RWSP vent and drain lines, and strainer debris
- Preparation and review of entry/exit logs and inspection records

The cleanliness, housekeeping and foreign materials exclusion program will be established consistent with guidance provided in RG 1.82 and GL 2004-02 to ensure that potential quantities of post-accident debris are maintained within the bounds of the analyses and design bases that support Emergency Core Cooling (ECC) and Containment Spray (CS) recirculation functions and ensure the long term core cooling requirements of 10 CFR 50.46 will be accomplished.

The cleanliness, housekeeping and foreign materials exclusion program also addresses other debris sources such as latent and miscellaneous debris inside containment. Consistent with MUAP-08001(R2), Sump Strainer Performance Evaluation (Ref. 6.2-34), the program will ensure that the quantity of miscellaneous debris inside containment will be limited such that the 200 ft^2

strainer surface area per sump uncertainty per MUAP-08001(R2) will be met. The cleanliness, housekeeping and foreign materials exclusion program to be implemented by the COL Applicant will also ensure that the quantity of latent debris will be limited to less than 200 lbm per MUAP-08001(R2). Refer to the responses to Question Nos. 06.02.02-35 and 06.02.02-36.

Impact on DCD

DCD Tier 2 subsections 6.2.2.3 and 6.2.8 will be revised to require the COL Applicant to establish programmatic controls as part of the cleanliness, housekeeping and foreign materials exclusion program to limit the quantity of miscellaneous and latent debris inside containment per MUAP-08001(R2). These subsections will be revised as shown in response to Question 06.02.02-31.

Impact on COLA

See the response to Question RAI 06.02.02-31 for the impact on COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: NO. 354-2585 REVISION 0

SRP SECTION: 06.02.02 – Containment Heat Removal System

APPLICATION SECTION: 6.2.2 & 6.3

DATE OF RAI ISSUE: 05/07/2009

QUESTION NO.: 06.02.02-34

Regarding programmatic controls taken to limit debris sources in containment provide a summary of the protective coating programmatic controls in place to control the introduction and use of coating material in containment and address coating deficiencies.

ANSWER:

Protective coatings to be utilized inside containment will be DBA qualified. In accordance with the requirements of Regulatory Guide 1.54, Revision 1 (July, 2000), a coating condition monitoring program that incorporates the guidance of ASTM D5163 will be established to conduct assessments of the conditions of the containment coatings during refueling outages. DCD Tier 2 Subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5) have been revised to include the requirement that the COL Applicant establish the coatings monitoring program.

Impact on DCD

DCD Tier 2 subsections 6.2.2.3 and 6.2.8 will be revised to require the COL Applicant to establish the coatings monitoring program. These subsections will be revised as shown in response to Question 06.02.02-31.

Impact on COLA

See the response to Question RAI 06.02.02-31 for the impact on COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-35

On page 6.2-49 of the DCD (Revision 1), the applicant discusses how preparation of a cleanliness program is the responsibility of the COL applicant and that this program addresses debris sources such as latent debris inside containment. What specific latent debris limits or controls does the DCD establish to enable the COL applicant to remain within the containment cleanliness design basis limit? Explain why this design basis limit is not contained within the COL item?

ANSWER:

MUAP-08001-P, Sump Strainer Performance Evaluation, Section 3.2 (Ref. 6.2-34) conservatively established an upper bound for the quantity of latent debris (unintended dirt, dust, paint chips, and fibers) inside containment at 200 lbm. The cleanliness, housekeeping and foreign materials exclusion program will ensure that the quantity of latent debris will be limited to less than 200 lbm to ensure ECC/CS strainer operation. DCD Tier 2 Subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5) will be revised to establish a limit of 200 lbm for latent debris inside containment.

Impact on DCD

DCD Tier 2 subsections 6.2.2.3 and 6.2.8 were revised to indicate that the quantity of latent debris inside containment will be limited to less than 200 lbm to ensure ECC/CS strainer operation. The cleanliness, housekeeping and foreign materials exclusion program to be implemented by the COL Applicant will ensure that the quantity of latent debris will be limited to less than 200 lbm. These subsections will be revised as shown in response to Question 06.02.02-31.

Impact on COLA

See the response to Question RAI 06.02.02-31 for the impact on COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: NO. 354-2585 REVISION 0

SRP SECTION: 06.02.02 – Containment Heat Removal System

APPLICATION SECTION: 6.2.2 & 6.3

DATE OF RAI ISSUE: 05/07/2009

QUESTION NO.: 06.02.02-36

The standard design for US-APWR does not define the specific type of materials for miscellaneous debris, such as tapes, tags or stickers, because these are controlled by the foreign material control program established by the plant owner. To deal with this uncertainty, a 200 ft2 penalty of sacrificial strainer surface area per sump is applied as a margin for future detail design and installation of the US-APWR (page 10, MUAP 08001). What specific miscellaneous debris limits or controls does the DCD establish to enable the COL applicant to remain within the foreign material 'uncertainty' (200 ft2) design basis limit or performance criteria? Explain why this design basis limit is not contained within the COL item?

ANSWER:

DCD Tier 2 Subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5) have been revised to specify the 200 ft^2 penalty for strainer surface area per sump that was applied as uncertainty to account for miscellaneous debris in accordance with MUAP-08001-P, Sump Strainer Performance Evaluation (Ref. 6.2-34). The cleanliness, housekeeping and foreign materials exclusion program will ensure that the quantity of miscellaneous debris will be limited such that the 200 ft^2 strainer surface area per sump uncertainty will be met to ensure ECC/CS strainer operation.

Impact on DCD

DCD Tier 2 Subsections 6.2.2.3 and 6.2.8, COL Item 6.2(5) will be revised to indicate the cleanliness, housekeeping and foreign materials exclusion program to be implemented by the COL Applicant will ensure that the quantity of miscellaneous debris will be limited such that the 200 ft^2 strainer surface area per sump uncertainty is met. The DCD will be revised as shown in response to Question 06.02.02-31.

Impact on COLA

See the response to Question RAI 06.02.02-31 for the impact on COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-37

DCD Tier 1, Section 2.4.4 (Emergency Core Cooling System) in the sub-section titled Design Description provides Figure 2.4.4-1 to show the functional arrangement of the ECCS. The functional arrangement depicts components that are further described in the section (un-numbered) titled "Key Design Features" and section 2.4.4.2 "ITAAC". The sump strainer is depicted in Figure 2.4.4-1and strainer ITAAC is prescribed (Table 2.4.4-5). However, there is no discussion or description of the strainer as a Key Design Feature. In contrast, DCD Tier 1, Section 2.11.3 (Containment Spray System) in the sub-section titled Design Description identifies the sump strainer as a Key Design Feature. The strainer is not identified in the functional arrangement figure (Figure 2.11.3-1) or tables discussing equipment or ITAAC (Table 2.11.3-5). The strainer is a dual function component, serving both ECCS and CSS. Tier 1 should accurately communicate this dual functionality and provide sufficient information in ECCS and CSS sections. One section may refer to the other section to avoid duplication of effort. For example, the staff recognizes that strainer ITAAC is currently provided in Section 2.4.4 (ECCS) and does not see value in duplicating this ITAAC in CSS. Rather, the CSS could refer to the strainer ITAAC provided in the ECCS section. Therefore, the NRC staff requests MHI to clarify Tier 1 information in relation to the sump strainer or provide the basis for not including a description of the sump strainer (ECCS key design feature) within DCD Section 2.4.4 (ECCS) and the basis for not including the sump strainer in the functional arrangement and ITAAC for the CSS (2.11.3).

ANSWER:

In response to RAI 348-2587, Question Nos. 14.03.11-38 and -39, the "Key Design Features" of the ECCS Design Description in Tier 1 Subsection 2.4.4.1 will be revised to include Emergency Core Cooling (ECC)/Containment Spray (CS) suction strainers' key design features that support the evaluations of sump strainer performance.

The Key Design Features of the CS system in Tier 1 Subsection 2.11.3.1 will be revised to refer to Subsection 2.4.4.1 for additional design features of the ECC/CS suction strainers.

Subsection 2.11.3.2, *Inspections, Tests, Analyses, and Acceptance Criteria*, will be revised to refer to ITAAC Item 7 in Table 2.4.4-5 that describes ITAAC for ECC/CS suction strainer performance."

Impact on DCD

No changes are proposed beyond the changes described above in response to RAI 348-2587.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-38

The APWR Design ensures that during a design basis event, the RWSP is replenished with water which has been released to the containment from the RCS sufficient to maintain adequate net positive suction head to the SI and containment spray/ residual heat removal (CS/RHR) pumps throughout the event. A key design feature that directly impacts the ability of the ECCS/CSS systems to perform this replenishment function is the system of transfer pipes and drain pipes, and their associated debris interceptors, that direct water back to the RWSP. For example, there are ten, 18 inch drain pipes with associated debris interceptors on the containment floor that return spray and break water to the RWSP. It does not appear that there is any design description of these key components in Tier 1. DCD Table 2.4.4-3 lists Emergency Core Cooling System Piping characteristics. Included in this table is NaTB solution transfer piping; essentially drain piping. The NRC staff requests MHI to address the basis for not including a discussion of the transfer/drain piping and their associated debris interceptors (as applicable) within DCD Tier 1 and any associated inspection and acceptance criteria; given that their replenishment functions are necessary for the ECCS to perform its safety function.

ANSWER:

MHI agrees that the systems of transfer pipes, refueling cavity drains discussed in the response to Question 06.02.02-25 are vital to the replenishment functions necessary for the ECCS to perform its safety function. As replied to Question 06.02.02-43, the debris interceptor does not have safety function, and therefore it does not need to discuss associated ITAAC program in the DCD Tier 1.

MHI will revise the DCD Tier 1 Section 2.4.4 (Emergency Core Cooling System) to include discussion of the important RWSP replenishment function provided by the systems.

Impact on DCD

- The DCD subsection 6.2.2.2.5 heading "Refueling Water Storage Pit", first paragraph will be revised as follows:

  The RWSP is the protected, reliable, and safety-related source of boric acid water for the containment spray and SI. (Section 6.3 describes the SI function for the US-APWR ECCS.)

The RWSP also is used to fill the refueling cavity in support of refueling operations. The RWSP is located on the lowest floor inside the containment, with a minimum 81,230 ft3 capability available, it is designed with sufficient capacity to meet long-term post-LOCA coolant needs, including holdup volume losses. Potential holdup areas within the containment are depicted in Figure 6.2.1-9. **The transfer piping and refueling cavity drain piping serves to the replenishment functions necessary for the ECCS to perform its safety function.** The total water volume held up in the containment is shown in Figure 6.2.2-7. Figure 6.2.2-7 shows the RWSP capacity requirements for refueling and LOCA. The RWSP is configured as a rough horseshoe-shaped box around the containment perimeter. The open end of the RWSP is oriented at the containment 0° azimuth (plant north), where the reactor coolant drain tank, reactor coolant drain pumps, and the containment sump are located. Figure 6.2.1-16 and Figure 6.2.1-17 present plan and sectional views of the RWSP. Subsection 6.2.1 describes the RWSP and its containment-related features and functions as part of the containment structure.

- DCD Table 3.2-2, Item number 17 on "Refueling Water Storage System" will be updated to add the following system, structure and components (SSCs).

Table 3.2-2 Classification of Mechanical and Fluid Systems, Components, and Equipment

System and Components	Equipment Class	Location	Quality Group	10 CFR 50 Appendix B (Reference 3.2-8)	Codes and Standards	Seismic Category
RWSP transfer piping	**2**	**PCCV**	**B**	**Yes**	**2**	**I**
Refueling cavity drain piping	**2**	**PCCV**	**B**	**Yes**	**2**	**I**

- The Key Design Features of the ECCS Design Description in Tier 1 Subsection 2.4.4.1 will be revised to add the following:

"RWSP replenishment function –The RWSP is equipped with transfer piping and refueling cavity drain piping to serve to the replenishment functions necessary for the ECCS to perform its safety function"

- Tier-1 Table 2.4.4-1 will be revised to add transfer piping and refueling cavity to describe its location as follows:

Table 2.4.4-1 Emergency Core Cooling System Location of Equipment and Piping

System and Components	Location
RWSP transfer piping	**Containment**
Refueling cavity drain piping	**Containment**

- Tier-1 Table 2.4.4-3 will be revised to add transfer piping and refueling cavity to describe its characteristics as follows:

Table 2.4.4-3 Emergency Core Cooling System Piping Characteristics

Pipe Line Name	ASME Code Section III Class	Leak Before Break	Seismic Category I
RWSP transfer piping	**2**	**No**	**Yes**
Refueling cavity drain piping	**2**	**No**	**Yes**

- Tier-1 Figure 2.4.4-1 "Emergency Core Cooling System (Sheet 4 of 4)"will be revised to add lines for transfer piping and refueling cavity drain piping.

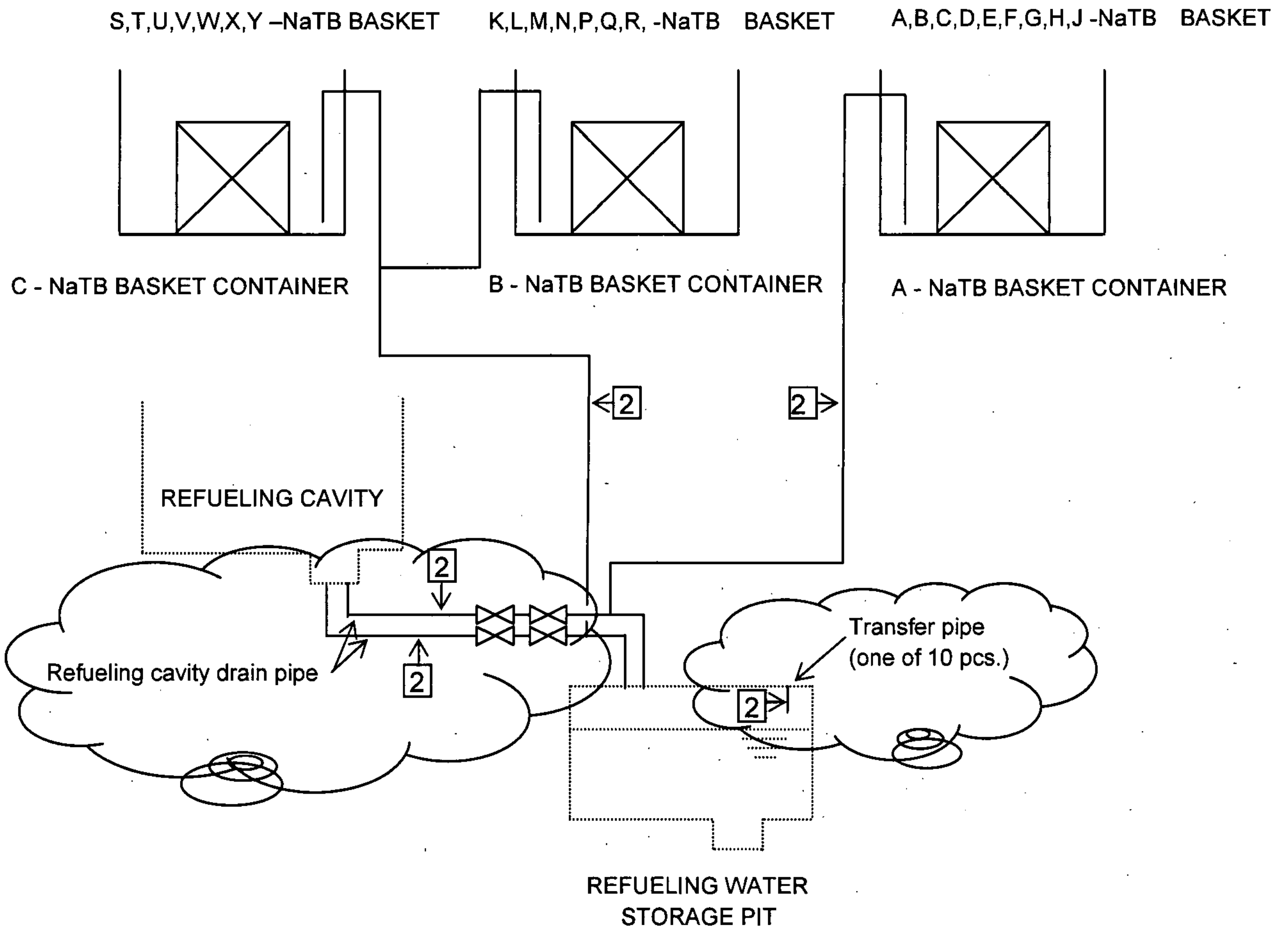


Figure 2.4.4-1 Emergency Core Cooling System (Sheet 4 of 4)

- No additional inspection and acceptance criteria for the transfer piping and the refueling cavity drain piping are required beyond the current Tier-1 Table 2.4.4-5.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-39

During a LBLOCA, water from the RWSP is pumped into containment and a portion of this water eventually collects on the containment floor. It is important to return this water back to the RWSP to maintain sufficient NPSH available to the CSS and ECCS pumps. For APWR there are gravity drains that allow water to flow from the containment floor to the RWSP. These gravity drains consist of ten 18" drain pipes that are dispersed around the containment floor at five (5) locations. No documentation was provided that demonstrates how the number and size of the openings was determined. Therefore, the NRC requests MHI discuss the technical basis for the number and size of the drain connections that serve to return water to the RWSP (not limited to containment floor; should include other credited drains such as refueling cavity). Describe methodology, key assumptions and justify how this is conservative with respect to NPSH available.

ANSWER:

As replied to Question 06.02.02-25, the transfer pipes and refueling cavity drains serve to return water to the RWSP. No other drains are assumed to provide make-up to the RWSP. Following is the technical basis for the number and size of the transfer pipes and refueling cavity drains.

<u>Transfer pipe</u>
Ten transfer pipes are provided at five (5) locations to collect post-LOCA blowdown water and containment spray water at elevation 25'-3" floor. The transfer pipe (18") is sized to assure the following capabilities:

- Ten transfer pipes are capable to drain water retained on the floor at elevation 25'-3" to the RWSP by gravity at maximum safety pumps operation during accident. Safety pumps are the safety injection (SI) pumps and the containment spray / residual heat removal (CS/RHR) pumps, and four train pumps operation is considered for this capability.

- The transfer pipe (18") is sufficiently sized to pass all "small" debris generated in the containment to the RWSP without blockage. (Refer the definition of "small" debris in the response to Question 06.02.02-22.)

Given that four train safety pumps are operated, the maximum flow rate per transfer pipe and associated pressure drop of transfer pipe were calculated as follows:

Q : Overflow rate per transfer pipe : 362.5 m^3/h [15,960 gpm/10 pipes]
P : Pressure drop of transfer pipe : 0.04 m

Since the water head for transfer pipe is 2.8 m, driving force by gravity against pressure drop of the pipe is sufficient. Therefore, the transfer pipes were designed to have drain capacity to maintain design basis of the minimum water level of the RWSP and NPSH available during accident.

Refueling cavity drain pipe
Two drain pipes are provided to collect containment spray water at lower level in the refueling cavity (See DCD Figure 6.2.1-9. The drain pipe (8") is sized to assure the following capabilities:

- Two drain pipes are capable to drain water retained on the refueling cavity floor to the RWSP by gravity at maximum containment spray pumps (i.e., four train pumps) operation.

- The drain pipe (8") is sufficiently sized to pass "small" debris which potentially falls on the refueling cavity without blockage.

Given that four containment spray pumps are operated, the maximum flow rate per drain pipe and associated pressure drop of the pipe were calculated as follows:

Q : Overflow rate per drain pipe : 278 m^3/h per one drain pipe [Note].
P : Pressure drop of transfer pipe : 1.0 m

Note: Assuming that one drain pipe was blocked and remain pipe is operable.

Since the water head for drain pipe is 4.7 m, driving force by gravity against pressure drop of the pipe is sufficient. Therefore, the drain pipes were designed to have drain capacity to maintain design basis of the minimum water level of the RWSP and NPSH available during accident.

The technical report MUAP 08001 section 3.7 "Upstream effect" will be revised with the above discussion to describe how the number and size of the openings to return water to the RWSP was determined.

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.

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-40

DCD Table 6.3-5 presents relevant ECC/CS Strainer data. Many strainer design values were provided such as design flow, surface area, and hole size. No design value for strainer head loss was provided. Please provide the basis for not including the strainer design value for head loss in DCD Table 6.3-5.

ANSWER:

MHI agrees that DCD Table 6.3-5 which presents relevant ECC/CS Strainer design values does not provide a value for strainer head loss. MHI will revise US-APWR DCD Chapter 6 (Engineered Safety Features) Table 6.3-5 to include the design value of "4.7 feet of water at 70 degree F" for strainer head loss.

Impact on DCD

The DCD Table 6.3-5 "Safety Injection System Design Parameters (Sheet 1 of 3)" will be updated as follows:

Description	Specification
ECC/CS Strainer	
Type	Disk layer type
Number	4 sets
Surface Area	3,510 ft^2 per train
Material	Stainless Steel
Design Flow	5,200 gpm per train
Hole diameter of perforated plate	0.066 inch
Debris Head Loss	**4.7 ft of water at 70 degree F**
Equipment Class	2
Seismic Category	I

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: NO. 354-2585 REVISION 0

SRP SECTION: 06.02.02 – Containment Heat Removal System

APPLICATION SECTION: 6.2.2 & 6.3

DATE OF RAI ISSUE: 05/07/2009

QUESTION NO.: 06.02.02-41

DCD Figure 6.2.1-9, "Outline of Paths that Solutions from the ECCS and CSS would follow in the Containment to the RWSP" depicts potential holdup areas within the Containment (see also Section 6.2.2.2.5 "Refueling Water Storage Pit"). On Figure 6.2.1-9, there is a cross–hatched region, indicative of holdup inventory that is not labeled. It is situated between two holdup areas labeled as C/V reactor coolant drain pump room and Containment recirculation air distribution chamber. Please describe and label this holdup area.

ANSWER:

The cross–hatched region situated between two holdup areas labeled as C/V reactor coolant drain pump room and Containment recirculation air distribution chamber is "a corridor" (elevation at 9'-6", See DCD Figure 1.2.3-4 and Figure 1.2.3-5) for the corridor connected between C/V reactor coolant drain pump room and Containment recirculation air distribution chamber. (Figure D-1 of MUAP-08001 is also referential for the location of the corridor.)

Impact on DCD

The DCD Figure 6.2.1-9 will be revises to clearly identify this holdup area.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-42

MUAP 08001-NP (R2), US-APWR Sump Strainer Performance Report, at the bottom of page 7 and continuing to page 8, states: "Particulate insulations are not used inside the containment. Therefore, only the RMI debris and fibrous debris are considered as the potential insulation debris for the US-APWR." However, section 6.1.1.2.1 on page 6.1-4 of US-APWR DCD (R1), states "Min-K based pipe insulation is prohibited in containment, unless encased in stainless steel cans." Explain the apparent conflict between the Sump Strainer Performance Report and the DCD in addressing particulate pipe insulation such as Min-K?

ANSWER:

MHI agrees that there is an inconsistency between statements in MUAP 08001-NP (R2), (US-APWR Sump Strainer Performance Report), and the DCD section 6.1.1.2.1 regarding the use of particulate insulation such as Min-K based pipe insulation.

Since the use of particulate based insulation is prohibited from the Containment, the DCD will be corrected as well.

Impact on DCD

Tier 2 DCD Section 6.1.1.2.1 fifth paragraphs on Page 6.1-4, will be updated with the following:

The use of particulate based insulation such as Min-K-based pipe insulation is prohibited in containment~~, unless encased in stainless steel "cans."~~ Non-metallic (thermal) insulation is controlled in accordance with RG 1.36 (Ref. 6.1-8) to control the leachable concentrations of chlorides, fluorides, sodium compounds, and silicates. Chapter 5, Subsection 5.2.3.2.3, provides further details on the external insulation requirements which are also applicable to ESFs. Close attention to regulatory requirements and guidance ensures material compatibility between US-APWR construction materials and ESF fluids.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: NO. 354-2585 REVISION 0

SRP SECTION: 06.02.02 – Containment Heat Removal System

APPLICATION SECTION: 6.2.2 & 6.3

DATE OF RAI ISSUE: 05/07/2009

QUESTION NO.: 06.02.02-43

RG 1.82 regulatory positions 1.1.1.6 and 1.1.1.8 discuss that trash racks or debris interceptors should be designed to withstand loads posed by expanding jets, missiles, and earthquakes. Each RWSP transfer pipe opening into the containment is protected from large debris and missiles by vertical debris interceptor bars that are capped by a ceiling plate. DCD Figure 6.2.2-12 depicts a transfer pipe debris interceptor. The NRC Staff requests that MHI describe the design basis for this debris interceptor. What design loads were assumed? What is the seismic classification? Provide basis for methodology and assumptions used to analyze this protective device.

ANSWER:

MHI agrees that the DCD Chapter 6, Table 6.2.2-2 Item numbers 1.1.1.6 and 1.1.1.8 do not provide the design basis for the debris interceptors such as assumed design loads and seismic classification. Following is the description of the debris interceptor of the US-APWR:

The debris interceptor consists of 6 round vertical rods and 1 top plate is provided at the transfer piping which collect and return recirculation water to the RWSP. The vertical rods are installed at an interval smaller than the inner diameter of transfer piping. This is to prevent transfer pipe from blockage by debris larger than the inner diameter of the pipe. However, as replied to Question 06.02.02-22, the design basis of postulated debris is defined as "small" and all of debris is considered reachable to the RWSP in the debris transport analysis. The debris interceptor is not credited to contribute safe ECC operation, and therefore it is classified as non-safety related component.

Given that one or two debris interceptors were blocked, remaining transfer pipes are still capable to drain return water to the RWSP without increasing hold-up volumes. (Refer the response to Question 06.02.02-39, for the information with respect to sufficient margin for driving force of transfer pipes drain capability.)

Impact on DCD

- The DCD subsection 6.2.2.2.5 heading "Refueling Water Storage Pit", third paragraph will be revised as follows:

The coolant and associated debris from a pipe or component rupture (LOCA), and the containment spray drain into the RWSP through transfer pipes, as shown in Figure 6.2.1-12. The pipes are installed through the RWSP ceiling, ending as openings into the containment floor at elevation 25 ft. - 3 in. Each transfer pipe opening into the containment is protected from large debris by vertical debris interceptor bars that are capped by a ceiling plate. There are ten transfer pipes distributed around the containment at elevation 25 ft. - 3 in**, as shown in Figure 6.2.1-16. The debris interceptor consists of 6 round vertical rods and 1 top plate is provided at the transfer piping which collect and return recirculation water to the RWSP. The vertical rods are installed at an interval smaller than the inner diameter of transfer piping. This is to prevent transfer pipe from blockage by debris larger than the inner diameter of the pipe. Since the design basis of postulated debris is defined as "small" and all of debris is considered reachable to the RWSP in the safety evaluation of the sump performance (Reference 6.2-34) The debris interceptor is not credited to contribute ECC operation, and therefore it is classified as non-safety related, seismic category II component.** To minimize containment humidity (due to evaporation from the RWSP), the transfer pipes extend from the containment floor, through the RWSP ceiling to below the normal 100% RWSP water level.

- DCD Table 3.2-2, Item number 17 on "Refueling Water Storage System" will be updated to add the following system, structure and components (SSCs).

Table 3.2-2 Classification of Mechanical and Fluid Systems, Components, and Equipment

System and Components	Equipment Class	Location	Quality Group	10 CFR 50 Appendix B (Reference 3.2-8)	Codes and Standards	Seismic Category
Debris interceptor	**5**	**PCCV**	**NA**	**No**	**5**	**II**

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/07/2009

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 354-2585 REVISION 0**

SRP SECTION: **06.02.02 – Containment Heat Removal System**

APPLICATION SECTION: **6.2.2 & 6.3**

DATE OF RAI ISSUE: **05/07/2009**

QUESTION NO.: 06.02.02-44

As part of its review of the US-APWR design aspects that address GSI-191, the staff reviewed the applicant's sump strainer performance to the applicable regulatory criteria 10CFR52.47 "Contents of Applications; technical information" using the guidance of RG 1.206 Combined License Applications for Nuclear Power Plants. RG 1.206 outlines information to be submitted with design certification applications that will facilitate review by the NRC staff. The following information items, outlined in Section C.I.6.2.2 Containment Heat Removal Systems, as it relates to sumps, were not provided in the US-APWR DC application and form the basis for this request for additional information:

1) Discuss [in the DCD FSAR] the types of insulation used inside the containment and identify where and in what quantities each type is used. As part of the DCD FSAR discussion, identify the design basis debris source term used for the strainer performance analysis to include LOCA generated and Latent debris types and quantities.

2) Describe the methods used to attach the insulation to piping and components.

ANSWER:

(The answer to Question 06.02.02-44 will be provided by July 17, 2009.)

Impact on DCD

(Associated DCD sections will be revised as per the final response.)

Impact on COLA

(There will be no impact on the COLA.)

Impact on PRA

(There will be no impact on the PRA.)