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July 2, 2012

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

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-12177

**Subject: Revised Response to US-APWR DCD RAI No.898-6275 Revision 3 (SRP 19)**

References:
1) "Request for Additional Information No. 898-6275 Revision 3, SRP Section 19 – Probabilistic Risk Assessment and Severe Accident Evaluation - Application Section: 19", dated January 30, 2012.
2) Letter MHI Ref: UAP-HF-12053 from Y. Ogata to U.S. NRC "MHI's Response to US-APWR DCD RAIs No.898-6275 Revision 3 (SRP 19)", dated February 28, 2012.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") the document entitled "Revised Response to Request for Additional Information No.898-6275 Revision 3".

Enclosed is the response to the RAI contained within Reference 1 and is the revised version of the response to RAI No. 898-6275 previously transmitted in Reference 2.

Please contact Mr. Joseph Tapia, General Manager of Licensing Department, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittal. His contact information is below.

Sincerely,

Y. Ogata

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

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Enclosure:

1. Revised Response to Request for Additional Information No.898-6275 Revision 3

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Docket No.52-021
MHI Ref: UAP-HF-12177

Enclosure 1

UAP-HF-12177
Docket No. 52-021

Revised Response to Request for Additional Information
No.898-6275 Revision 3

July 2012

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**07/02/2012**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** **NO. 898-6275 REVISION 3**

**SRP SECTION:** **19 – Probabilistic Risk Assessment and Severe Accident Evaluation**

**APPLICATION SECTION:** **19**

**DATE OF RAI ISSUE: 01/30/2012**

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**QUESTION NO.: 19-564**

In accordance with guidance provided in SRP Section 19.1 and RG 1.206, please revise as necessary Sections 19.1.1 and 19.1.2 of the US-APWR DCD Revision 3 to address the following issues.

1. Define which PRA (i.e., design-specific PRA or plant-specific PRA) is in consideration when mentioning "PRA" in these sections. This action is needed to clearly separate the responsibility of the DC applicant, COL applicant, and COL holder on the use, update, and upgrade of the PRA. In addition, for COL holders, 10 CFR 50.71(h)(2) states that "…The PRA must be upgraded every 4 years until the permanent cessation of operations under 10 CFR 52.110(a)." The term mentioned herein is "upgraded" but not "updated," which has a different meaning (see Regulatory Guide 1.200 for characteristics and attributes of an upgrade). It should also be noted that there may be situations where a PRA upgrade is needed more frequently than the four-year cycle, as for instance to support a new risk-informed application. Furthermore, no specific frequency is defined in the rule for PRA update.
2. Revise the discussions on Pages 19.1-1 and 19.1-4 to clearly state that the PRA-based SMA is being used to assess US-APWR seismic risk but not "PRA" as mentioned.
3. During the operational phase, the use of the PRA during plant operations in support of licensee programs shall be identified and described by the COL holder. Remove unsuitable information/discussion from the design control document and develop a COL action item.
4. Revise Section 19.1.2.4 to clearly describe the US-APWR design-specific PRA maintenance and upgrade program.

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**ANSWER:**

The following items summarize changes to be made in the next DCD revision, as indicated in the attached markups.

1. Sections 19.1.1 and 19.1.2 will be revised to clarify the responsibility of the DC applicant, COL applicant, and COL holder on the use, maintenance and upgrade of the PRA.

2. Section 19.1 will be revised to clearly state the use of PRA-based seismic margin analysis in the US-APWR seismic risk assessment.

3. Section 19.1.1.4 will be revised to specify that the use of PRA during the operational phase will be specified by the COL applicant. COL action item 19.3(6) was updated, and a new COL action item was developed and included in Table 1.8-2 and Section 19.3 [See COL 19.3(8) in attached DCD mark up].

4. Section 19.1.2.4 will be revised to describe the design specific PRA maintenance and upgrade program. A new COL action item has been developed and will be included in Table 1.8-2 and Section 19.3 [See COL 19.3(9) in attached DCD mark up].

**Impact on DCD**

See attached DCD mark up (Attachment-1) for changes to Chapters 1 and 19.

**Impact on R-COLA**

COL 19.3(6) will be revised and new COL action items will be added to the DCD Chapters 1.8 and 19.3. The R-COLA will be revised to address the revised and new COL action items.

**Impact on S-COLA**

COL 19.3(6) will be revised and new COL action items will be added to the DCD Chapters 1.8 and 19.3. The S-COLA will be revised to address the revised and new COL action items.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Topical / Technical Report**

There is no impact on topical and technical reports.

**Table 1.8-2 Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 36 of 36)**

| COL ITEM NO. | COL ITEM | |
|---|---|---|
| *COL 19.3(5)* | ~~*Deleted*~~*The COL Applicant will identify a milestone for completing a comparison of the as-built SSC HCLPFs to those assumed in DCD Subsection 19.1.5.1. Deviations from the HCLPF values or other assumptions in the seismic margins evaluation shall be analyzed to determine if any new vulnerability have been introduced.* | MIC-03-01-0 0011 |
| *COL 19.3(6)* | ~~*The COL Applicant develops an accident management program which includes severe accident management procedures that capture important operator actions. Training requirements are also included as part of the accident management program.*~~*The COL Applicant develops or describes an accident management program which includes emergency operating procedures, consideration of risk-significant operator actions listed in DCD Table 19.1-119, training, and human reliability related severe accident guidance programs. Insights gained from the design specific PRA, including insights created by the incorporation of site and plant-specific information available at the COL application phase (for aspects of the design which are not bounded by the Standard Plant PRA), are to be reflected appropriately.* | MIC-03-01-0 0012<br>DCD_19-508<br>DCD_19-564 |
| *COL 19.3(7)* | *The COL Applicant will provide a milestone for completing the equipment survivability assessment of the as-built equipment required to mitigate severe accidents (electrical penetrations, hydrogen igniters and containment pressure (wide range)) to provide reasonable assurance that they will operate in the environmental conditions resulting from hydrogen burns associated with severe accidents for which they are intended and over the time span for which they are needed.* | DCD_06.02. 05-45 |
| *COL 19.3(8)* | *The COL applicant will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the operational phase.* | DCD_19-564 |
| *COL 19.3(9)* | *The COL applicant will describe the PRA maintenance and upgrade programs.* | DCD_19-564 |

## 19.1 Probabilistic Risk Assessment

The scope of the US-APWR PRA for the DCD and COL application includes a Level 1 and Level 2 PRA for internal and external events(including flooding~~,~~ and fire~~, and seismic~~) at full-power, low-power and shutdown (LPSD) conditions. PRA-based seismic margin analysis (SMA) is used for seismic risk evaluation. The design-specific PRA refers specifically to the PRA generated by the DC applicant. The site-specific PRA refers specifically to the PRA generated by the COL applicant. DCD_19-564 DCD_19-564 S01

The Level 1 evaluation of internal events at full-power conditions is based on the basic methodology and approach given in ASME/ANS RA-S-2008 and associated addenda (Reference 19.1-49, 19.1-50) and is comprised of the following technical elements:

- Initiating event analysis
- Event tree analysis
- System dependencies
- Success criteria analysis
- System analysis
- Data analysis
- Common cause analysis
- Human reliability analysis (HRA)
- Quantification and insights

The evaluation of internal events at LPSD conditions uses the same basic methods as the evaluation of internal events at full-power. A representative set of initiating events is chosen and modeled for a bounding set of plant operational states (POSs).

The evaluation of a flooding external event is based on the basic methodology and approach given in ASME/ANS RA-S-2008 and associated addenda, NUREG/CR-2300, and NRC technical report designation NUREG-1150 (Reference 19.1-4, 19.1-5, 19.1-49, 19.1-50). A qualitative evaluation identifies flood areas and sources and a quantitative evaluation evaluates initiating events and flood scenarios.

The evaluation of a fire external event is based on the basic methodology and approach given in National Fire Protection Association (NFPA) 805 and NUREG/CR-6850 (Reference 19.1-6, 19.1-7). A qualitative evaluation identifies fire compartments and components and a quantitative evaluation evaluates initiating events and fire scenarios.

The evaluation of a seismic external event is based on a ~~seismic margin analysis (~~PRA-based SMA~~)~~ consistent with ASME/ANS RA-S-2008 and associated addenda (Reference 19.1-50). The PRA-based SMA model is based on the internal events of the PRA model expanded to account for structural dependencies. The PRA-based SMA estimates the plant-level seismic margin and accident sequences, identifies potential DCD_19-564

Other external events (high winds and tornadoes, external floods, transportation accidents, nearby facility accidents, and aircraft crashes) are subject to screening criteria consistent with ASME/ANS RA-S-2008 and associated addenda.

The Level 2 PRA results in LRFs for internal events at full power and the evaluation involves the following:

- Plant damage state (PDS) analysis
- Accident progression analysis
- Quantification

The primary guidance for this analysis is ASME/ANS RA-S-2008 and addenda, NUREG/CR-2300, and RG 1.200 (Reference 19.1-4, 19.1-9, 19.1-49, 19.1-50). MAAP version 4.0.6 (Reference 19.1-10) is employed to evaluate severe accident phenomena.

The Level 2 evaluation of the flooding and fire external events at full-power conditions is based on the same approach as for internal events. Fault trees are modified to take into account flood/fire induced failures of severe accident mitigation features and these fault trees are mapped into the internal events through the associated PDSs.

For events at LPSD, the LRFs are conservatively assumed to be the same as the core damage frequencies, with a simple bounding technique.

## 19.1.1 Uses and Applications of the PRA

### 19.1.1.1 Design Phase

The design-specific US-APWR PRA is an integral part of the design process and has been used to optimize the plant design with respect to safety. The PRA models and results have influenced the selection of design alternatives such as four train core cooling systems, an in-containment refueling water storage pit (RWSP), and full digital instrumentation and control (I&C) systems. DCD_19-564

The US-APWR is expected to perform better than current operating plants in the area of severe accident performance since prevention and mitigation of severe accidents have been addressed during the design stage, taking advantage of PRA results and severe accident analysis. The PRA results indicate that the US-APWR design results in a low level of risk and meets the CDF, LRF, and containment performance goals for new generation pressurized water reactors (PWRs).

At the design phase, the design-specific PRA results have been used as information providing input to technical specifications (Chapter 16), RAP (Chapter 17, Section 17.4), the security plan, and other design areas. ~~PRA insights are utilized to develop risk-managed technical specifications (RMTS) and surveillance frequency control program (SFCP) in accordance with Reference 19.1-11 and 19.1-44, respectively.~~ PRA was used to determine the components and instruments that would be subjected to ~~RMTS and SFCP~~risk managed technical specifications (RMTS) and surveillance frequency control program (SFCP). DCD_19-564 DCD_19-564

Information regarding loss-of-coolant accident (LOCA) scenarios followed by failures of accumulators and the risk impact of accumulator unavailability were used to confirm the applicability of standard technical specification requirements to the US-APWR design so the applicability of standard technical specification were considered applicable to the US-APWR design.

Sensitivity analysis results regarding reliability of the protection and safety monitoring system (PSMS) were used to confirm the completion time and surveillance frequencies in the US-APWR technical specification are sufficient not to degrade plant safety. Sensitivity analysis results showed that the changes from the standard technical specification, increases in surveillance frequencies, would not result in significant increase in risk.

### 19.1.1.2 Combined License Application Phase

#### 19.1.1.2.1 Uses of Probabilistic Risk Assessment in Support of Licensee Programs

~~The~~A site-specific PRA in the Combined License Application (COLA) phase will be used to support licensee programs such as the human factors engineering program (Chapter 18) and the severe accident management program. The PRA in the COLA phase will also be utilized to support implementation of 10 CFR 50.65 (Reference 19.1-12), the maintenance rule, and the technical specification as well as the reactor oversight process including the mitigating systems performance index and the significance determination process. DCD_19-564

The PRA may require updating to assess site-specific information (e.g., ultimate heat sink) and associated site-specific external events (high winds and tornadoes, external floods, transportation, and nearby facility accidents).

#### 19.1.1.2.2 Risk-Informed Applications

~~As discussed in Subsection 19.1.1.1,~~Site-specific PRA insights are utilized to develop ~~site-specific~~ risk-managed technical specifications~~, RAP, and other risk-informed applications~~ if the COL applicant chooses to adapt risk-managed technical specifications. DCD_19-564

### 19.1.1.3 Construction Phase

~~The~~A site-specific PRA may require updating during the construction phase to reflect site-specific characteristics or design changes. The PRA may also be used to support licensee programs or risk-informed applications as appropriate. DCD_19-564

#### 19.1.1.3.1 Uses of Probabilistic Risk Assessment in Support of Licensee Programs

The PRA in the construction phase will be used to support licensee programs such as the human factors engineering program (Chapter 18) and the severe accident management program.

#### 19.1.1.3.2 Risk-Informed Applications

The ~~updated~~ PRA in the construction phase will be ~~reflected to~~updated and upgraded as necessary to support risk-informed applications ~~currently planned for implementation~~ during the construction phase. DCD_19-564

#### 19.1.1.4 Operational Phase

~~The PRA will be used during the operational phase to support licensee programs or risk-informed applications as appropriate, such as the risk-managed technical specification (RMTS) discussed in chapter 16.~~A COL applicant that references the US-APWR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the operational phase. DCD_19-564

#### 19.1.1.4.1 Uses of Probabilistic Risk Assessment in Support of Licensee Programs

~~The PRA will be used in the operational phase to support licensee programs such as the human factors engineering program (Chapter 18), the severe accident management program, the maintenance rule, and the reactor oversight program.~~ A COL applicant that references the US-APWR design certification will describe the uses of PRA in support of licensee programs being implemented during the operational phase. DCD_19-564

#### 19.1.1.4.2 Risk-Informed Applications

~~The PRA will be updated to reflect risk-informed applications during the operational phase.~~A COL applicant that references the US-APWR design certification will identify and describe risk-informed applications being implemented during the operational phase. DCD_19-564

### 19.1.2 Quality of PRA

The quality of the PRA for the US-APWR is measured in terms of its appropriateness with respect to scope, level of detail, and technical acceptability. RG 1.200 (Reference 19.1-9) was reviewed to ensure that the quality of the US-APWR PRA is consistent with the NRC's expectations. ~~The quality of the PRA is sufficient to provide confidence in the results, such that the PRA may be used in regulatory decision-making and to support risk-informed applications.~~ DCD_19-510

The following methods are utilized during development of the PRA to ensure that pertinent requirements of 10 CFR 50, Appendix B (Reference 19.1-13) are met:

- Use of qualified personnel
- Use of procedures that ensure control of documentation, including revisions, and provide for independent review, verification, or checking of calculations and information
- Documentation and maintenance of records, including archival documentation, as well as submittal documentation

- Use of procedures that ensure appropriate attention and corrective actions are taken if assumptions, analyses, or information used previously are changed or determined to be in error.

### 19.1.2.1 PRA Scope

The scope of the ~~design-specific and site-specific~~ US-APWR PRA for the DCD and COL application includes a Level 1 and Level 2 PRA ~~for internal and external events (including flooding, fire, and seismic)~~for internal, external events (including flooding and fire) and a PRA-based SMA at full-power, and LPSD conditions. The design-specific PRA refers specifically to the PRA generated by the DC applicant. The site-specific PRA refers specifically to the PRA generated by the COL applicant. DCD_19-564 DCD_19-564 S01

### 19.1.2.2 PRA Level of Detail

The US-APWR realistically reflects the actual plant design, planned construction, anticipated operational practices, and relevant operational experience. The approach, methods, data, and computer codes that are used, as documented throughout this chapter, are compliant with industry standard codes and practices. The level of detail is sufficient to ensure that the impacts of designed-in dependencies are correctly captured. The level of detail of the PRA is sufficient to provide confidence in the results such that the PRA may be used ~~in regulatory decision-making~~ to support ~~risk-informed applications~~licensee programs and design activities in design phase. DCD_19-564

### 19.1.2.3 PRA Technical Adequacy

The quality of the methodologies, processes, analyses, and personnel associated with the US-APWR PRA comply with the provisions for nuclear plant quality assurance. Toward this end, the US-APWR PRA adheres to the recommendations provided in RG 1.200 pertaining to quality and technical adequacy. The US-APWR incorporates the technical elements of an acceptable PRA shown in Table 1 of RG 1.200 (Reference 19.1-9), and is consistent with the technical characteristics and attributes given in Table 2 through Table 10 of RG 1.200. ~~The PRA has been developed in accordance with industry consensus standards as described in Section 19.0, and has been subjected to a peer review process as defined in ASME/ANS RA-S-2008 and associated addenda (Reference 19.1-49, 19.1-50) and as outlined in the Nuclear Energy Institute (NEI) peer review guide (Reference 19.1-14).~~ DCD_19-510

### 19.1.2.4 PRA Maintenance And Upgrade

The objective of the PRA maintenance and upgrade program is to ensure that the PRA will be maintained and upgraded so that its representation of the as designed, as-to-be built, and as-to-be operated plant is sufficient to support the applications for which the PRA is being used. The PRA will be under configuration control and the program will contain the following key elements:

- A process for monitoring PRA inputs and collecting new information
- A process that maintains and upgrades the PRA to be consistent with the as-built, as-operated plant

- A process that ensures the cumulative impact of pending changes is considered when applying the PRA
- A process that evaluates the impact of changes on previously implemented risk-informed decisions that have used the PRA
- A process that maintains configuration control of computer codes used to support PRA quantification
- Documentation of the program

PRA maintenance involves updating of PRA models to reflect plant changes such as modifications, procedure changes, or plant performance. A PRA upgrade involves the incorporation into the PRA model of new methodologies or significant changes in scope or capability. Those changes could include items such as new human error analysis methodology; new data update methods; new approaches to quantification or truncation; or new treatments of common cause failure (CCF).

During the design phase, changes to PRA inputs and discovery of new information will be evaluated to determine whether a PRA maintenance or upgrade is warranted. Changes to the PRA impacting risk insights or key assumptions will be prioritized to ensure that the most significant changes are incorporated as soon as practical and associated documentation is updated accordingly. Other changes will be incorporated during the next PRA update. DCD_19-564

In accordance with 10 CFR 50.71(h)(1) (Reference 19.1-15), prior to the scheduled date for initial loading of fuel, a plant-specific PRA that covers initiating events and modes for which NRC-endorsed consensus standards on PRA exist one year prior to the scheduled date for initial loading of fuel will be developed. The plant-specific PRA will reflect the as-built plant. The plant-specific PRA model will utilize the US-APWR DCD PRA model as a baseline. Any additional modeling changes resulting from the plant-specific design, departures from the design used in the US-APWR DCD PRA, insights from procedure development and operator training, or other PRA modeling changes that are identified subsequent to the completion of the US-APWR DCD PRA will also be utilized. The PRA-based risk insight differences between the plant-specific PRA and the US-APWR DCD PRA will be evaluated. During the construction phase, plant walk-downs confirming PRA assumptions will be conducted. ~~Plant walk-downs to confirm that the assumptions used in the PRA remain valid will also be conducted.~~ DCD_19-564 DCD_19-564 S01

During operation, PRA will be maintained and updated in accordance with approved station procedures on a periodic basis not to exceed ~~two refueling cycles~~four years. DCD_19-564

~~Changes in PRA inputs or discovery of new information will be evaluated to determine whether the new or changed information warrants a PRA maintenance or upgrade. Changes that would impact risk-informed decisions will be prioritized to ensure that the most significant changes are incorporated as soon as practical. Other changes will be incorporated during the next PRA update.~~

Changes to the PRA due to PRA maintenance and PRA upgrade will meet the ~~risk assessment~~ technical requirements of the NRC-endorsed PRA standards (Reference

19.1-49 and 19.1-50). ~~Upgrades of the PRA will receive a peer review in accordance with the requirements of the NRC endorsed PRA standards, but will be limited to aspects of the PRA that have been upgraded.~~ DCD_19-510

~~The PRA will be updated to reflect plant experience, operational experience, and PRA modeling changes, consistent with the NRC endorsed standards. These standards are described in Section 19.1 and were in existence one year prior to the issuance of the maintenance update scheduled in compliance with 10 CFR 50.71 specified criteria and intervals.~~ DCD_19-564

### 19.1.3 Special Design/Operational Features

Design and operational features of the US-APWR that result in improved plant safety as compared to currently operating nuclear power plants, include the following:

- Mechanical four train systems with direct vessel injection (DVI) system design
- Elimination of the need for low-head safety injection (LHSI) pumps by utilizing an advanced accumulator injection system
- Elimination of recirculation switching by an in-containment RWSP
- Enhanced safety through the use of four trains of safety electrical systems
- Upgraded piping design pressure for the residual heat removal system (RHRS)

The major unique features of the US-APWR related to PRA scope are

- Four train core cooling - High reliability due to four advanced accumulators and a four train high head injection system
- In-containment RWSP - Elimination of recirculation switchover enhances reliability of long-term core cooling after a loss-of-coolant accident (LOCA)
- Full Digital I&C - Diverse actuation system (DAS) installed as a counter-measure against common cause failures in software of safety I&C
- Four train safety-related systems separated by physical barriers

The four train system design reduces the US-APWR system dependencies when compared to those associated with current United States PWRs. System dependencies are discussed in Subsection 19.1.4.1. The upgraded design pressure of the RHRS results in a negligible frequency of occurrence of an interfacing system LOCA

#### 19.1.3.1 Design/Operational Features for Preventing Core Damage

Key preventive features that are intended to minimize initiation of plant transients, arrest the progression of plant transients, and prevent severe accidents include the following safety systems:

- High head injection system (Chapter 6, Section 6.3.2)

| | | |
|---|---|---|
| COL 19.3(6) | ~~The COL Applicant develops an accident management program which includes severe accident management procedures that capture important operator actions. Training requirements are also included as part of the accident management program.~~The COL Applicant develops or describes an accident management program which includes emergency operating procedures, consideration of risk-significant operator actions listed in DCD Table 19.1-119, training, and human reliability related severe accident guidance programs. Insights gained from the design specific PRA, including insights created by the incorporation of site and plant-specific information available at the COL application phase (for aspects of the design which are not bounded by the Standard Plant PRA), are to be reflected appropriately. | DCD_19-508<br>DCD_19-564 |
| COL 19.3(7) | The COL Applicant will provide a milestone for completing the equipment survivability assessment of the as-built equipment required to mitigate severe accidents (electrical penetrations, hydrogen igniters and containment pressure (wide range)) to provide reasonable assurance that they will operate in the environmental conditions resulting from hydrogen burns associated with severe accidents for which they are intended and over the time span for which they are needed. | DCD_06.02.05-45 |
| COL 19.3(8) | The COL applicant will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the operational phase. | DCD_19-564 |
| COL 19.3(9) | The COL applicant will describe the PRA maintenance and upgrade programs. | DCD_19-564 |