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July 9, 2010

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-10198

Subject: MHI's Responses to US-APWR DCD RAI No. 595 COLP-4519 REVISION 0

Reference: 1) "Request for Additional Information No. 595 COLP 4519 REVISION 0, SRP Section: 18 - Human Factors Engineering, Application Section: 18.7" dated June 8, 2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 595 COLP-4519 Revision 0."

Enclosed are the responses to the RAI contained within Reference 1.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is below.

Sincerely,

Y. Ogata

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

Enclosure:

1. Responses to Request for Additional Information No. 595 COLP-4519 REVISION 0

DD81
NRO

CC: J. A. Ciocco
C. K. Paulson

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Docket No. 52-021
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Enclosure 1

UAP-HF-10198
Docket No. 52-021

Responses to Request for Additional Information No. 595 COLP-4519
REVISION 0

July 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/9/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 595 COLP 4519 REVISION 0**
SRP SECTION:	**18 - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.7 HUMAN RELIABILITY ANALYSIS**
DATE OF RAI ISSUE:	**6/8/2010**

QUESTION NO. 18-85

Criterion: In accordance with NUREG-0711, Section 1.2.1, an applicant in expected to provide implementation plan level details as well as results summary details, and the applicant may choose to submit them as two reports or one. For more complex elements, additional reports may be submitted to address all criteria. When additional information is need it is identified in this section of each element.

Question:

The MHI Human Reliability Analysis Implementation Plan is described in multiple documents, primarily MUAP DC-0018, Rev. 2, 'Chapter 18 Human Factors Engineering,' and MUAP 07007-P, Rev. 3, 'HSI System Description and HFE Process.'

The staff also reviewed the following additional MHI US APWR documents for the analysis of implementation plan level details and results summary details:

- MUAP 09019 P, Rev 0, 'US-APWR HSI Design';
- MUAP 08014 P, Rev. 0, Part 1 of 2 – Phase 1a (ML0900903852) and MUAP 08014 P, Part 2 of 2 – Phase 1a (ML0900903852)

Staff is unclear of the relationship(s) among the above documents as they relate to the NUREG-0711 Section 1.2.1 guidance. The applicant is requested to explain the hierarchy and the relationships among these documents. Please include how these documents provide the implementation plan level details and results summary details.

ANSWER:

MUAP DC-0018, Rev. 2, 'Chapter 18 Human Factors Engineering' is specific for the US-APWR which describes in the most general terms the HFE process.
MUAP-07007, Rev. 3, 'HSI System Description and HFE Process' is the document that extends the description from DC-0018 to a more detailed programmatic level of the HFE and HRA as they apply to the US-APWR and plant modernization programs. This document describes the various analytical methods that are used in support of the HRA

and the design and introduces the integration of the HRA results into the complete HSI design process.
MUAP-09019, Rev 0; as discussed with the staff during the March 17, 2010 HFE public meeting, part 1 and part 2, section 2, represent, respectively, first the details of the overall HFE Implementation Plan, describing the links between all the HFE elements, and second the HRA Implementation Plan and Results Summary. Together these two parts provide the level of detail for the Implementation Plan and Summary Report for the US-APWR HRA as described in NUREG 0711 section 1.2.1.
MUAP-08014, Rev. 0 uses the US-APWR specific preliminary HRA results for the OER and validation and verification of Phase 1a.

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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QUESTION NO. 18-86

In accordance with NUREG-0711, 7.4 (1), 'Risk-important human actions should be identified from the PRA/HRA and used as input to the HFE design effort. These actions should be developed from the Level 1 (core damage) PRA and Level 2 (release from containment) PRA including both internal and external events. They should be developed using selected (more than one) importance measures and HRA sensitivity analyses to provide reasonable assurance that an important action is not overlooked because of the selection of the measure or the use of a particular assumption in the analysis.'

Question:

MUAP 09019 states that HRA sensitivity analysis utilizing Fussell-Vessely (FV) and Risk Achievement Worth (RAW) is used to identify risk important HAs when complete data on the design is not available.

In Section 2.4.2.1 of MUAP 09019 P, the applicant states, "Risk importance measures, such as Risk Achievement Worth (RAW) and Fussell-Vessely (FV)... were used to measure risk importance of HAs."

Staff requests the applicant provide clarification on the use of the term 'such as'. For example, were other measures of risk importance used to determine the importance of HAs in place of, or in addition to, FV and RAW? Also clarify whether other measures will be used in the future in place of FV and RAW. If other measures were or will be used, indicate what measures.

ANSWER:

MHI uses only RAW and FV for the measurements of HRA sensitivity analysis of selection of risk-important human actions. MHI will correct the description of Section 2.4.2.1 second paragraph second sentence of the MUAP-09019-P as follows in the next revision (changes are underlined);

"Risk importance measures of ~~such as~~ the Risk achievement worth (RAW) and Fussell-Vessely (FV) importance measures, which can be derived from the PRA, were used to measure risk importance of HAs."

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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DATE OF RAI ISSUE:	**6/8/2010**

QUESTION NO. 18-87

Criterion: In accordance with NUREG-0711, 7.4 (1), Risk-important human actions should be identified from the PRA/HRA and used as input to the HFE design effort. These actions should be developed from the Level 1 (core damage) PRA and Level 2 (release from containment) PRA including both internal and external events. They should be developed using selected (more than one) importance measures and HRA sensitivity analyses to provide reasonable assurance that an important action is not overlooked because of the selection of the measure or the use of a particular assumption in the analysis.

Question:

As an example of the sensitivity analysis, in section 2.4.2.1 of MUAP 09019, as well as Appendix 2.10.1, the Applicant states that risk important HAs for LPSD are identified based on the following criteria:

- Risk important HAs during mid-loop state
  - Human actions that meet the importance criteria shown below are risk important: FV ≥ 0.005 or RAW ≥2.
- Risk important human action during POSs other than mid-loop state
  - HAs that are risk important during mid-loop are also risk important during other POSs.
  - HAs that are not credited in the PRA for the mid-loop state are all risk important. [Emphasis added.]

The staff currently interprets this last bullet to commit that all actions for plant operational state (POS) in mid-loop state will be considered risk important; this would include actions that are not typically relevant to the PRA. The staff requests the applicant to clarify whether this statement is correct as written and that all actions for plant operational state (POS) in mid-loop state will be considered risk important, including actions that are not typically relevant to the PRA. Staff are aware that this could lead to a large number of

HAs to be 'specially addressed'. If the statement is correct as written, staff requests the applicant provide information on how they will ensure that ALL the HAs that would be derived from the mid-loop PRA will be specially addressed.

ANSWER:

Due to the basic intent of the application of PRA/HRA in the identification, through probabilistic bounding analysis, of important human actions that require inclusion in the design process and the impracticality, as pointed out by the NRC question, of deterministically including "all" human actions, it is the intent of MHI to identify and assess the HSI design through the HFE process those actions typically contained in a PRA and relevant to the US-APWR design. MHI will analyze all the tasks based on the developed normal operating procedure for the mid-loop operation of the US-APWR.
MHI will revise MUAP-09019 Part 2 Section 3, to replace last sentence of subsection 3.2 as follows (changes are underlined);

"Detail level of the operating task analysis will be conducted in conjunction with ERG and General Operating Procedures (GOP) development. The results will be documented in the Phase 2 V&V report."

The result of the task analysis will reflect to the HSI design, training program and integrated V&V (Phase 2) plan for the US-APWR.

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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QUESTION NO. 18-88

Criterion: In accordance with NUREG-0711, 7.4 (2) 'Risk-important HAs and their associated tasks and scenarios should be specifically addressed during function allocation analyses, task analyses, HSI design, procedure development, and training. This will help verify that these tasks are well supported by the design and within acceptable human performance capabilities (e.g. within time and workload requirements).

Question:

Previously, staff asked RAI 18.0-40, (ML0918303502) which asked MHI to provide discussion of how risk-important human actions will be will be used as input to the HFE design. MHI responded that risk-important HAs and their tasks and scenarios are specifically addressed during Task Analysis, Function Allocation Analysis, HSI design, procedure development and training development. V&V activities are designed to 'specifically address' human performance for risk-important HAs, and validation scenarios all human actions shown by the HRA to be risk significant. Response to RAI 18-42 indicated that the Task Analysis Report and the Functional Analysis Report would provide the detail on how HAs were specifically addressed in these design elements. Staff reviewed the Task Analysis Report and the Functional Allocation Report and were unable to identify the information which would detail how risk important HAs are specifically addressed in these elements. The commitment that risk important HAs are specifically address is a repetition of the guidance provided in NUREG-0711, which staff uses for reviews. Staff cannot determine a reasonable assurance of safety when the information provided is the guidance for the review.

Staff request information to explain how risk-important HAs will be specifically addressed in the HF elements included in the criteria.

ANSWER:

The risk-important HAs have been specifically addressed in the implementation plans for the HSI design, procedure development and training development and V&V activities. For example, the training program will be designed to assure that all risk important

human actions identified by the HRA will be included as one of the training objectives to assure that the operating crews have the needed knowledge to minimize these actions and their effects on the plant.

Based on the public meeting on 17th March 2010, the following Technical Reports have been submitted to the NRC.

-MUAP-10009 HSI Design Implementation Plan
-MUAP-10010 Operating Procedure Development Implementation Plan
-MUAP-10011 Training Program Development Implementation Plan
-MUAP-10012 Verification and Validation Implementation Plan

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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APPLICATION SECTION:	**18.7 HUMAN RELIABILITY ANALYSIS**
DATE OF RAI ISSUE:	**6/8/2010**

QUESTION NO. 18-89

Criterion: In accordance with NUREG-0711, 7.4 (2), Risk-important HAs and their associated tasks and scenarios should be specifically addressed during function allocation analyses, task analyses, HSI design, procedure development, and training. This will help verify that these tasks are well supported by the design and within acceptable human performance capabilities (e.g. within time and workload requirements).

Question:

The DCD states that the guidelines for incorporating the risk important HAs into the other design elements are contained in NUREG/CR-6689. Staff are aware that NUREG/CR-6689, "Proposed Approach for Reviewing Changes to Risk-Important Human Actions," was superseded by NUREG-1764. NUREG 1764 provides an approach for assessing the human performance aspects of changes to operator actions that are applicable primarily for plant modifications, but it is not clear how it provides guidance on incorporation of important HAs into HFE design elements of a new plant design. Staff request clarification of this reference, and identification of applicable guidance and methods for incorporation of risk important HAs into the HFE design elements of a new design.

ANSWER:

The NRC staff is right that NUREG/CR-6689 has been superseded by NUREG-1764.

MHI uses NUREG-1764 as a reference to identify risk-important HAs to be incorporated to the US-APWR HFE design. Although, NUREG-1764 has the primary application for the review of licensee submittals containing risk informed justification of plant modifications that impact human actions identified in the plant's safety analysis. MHI used this report to compare predecessor PWR plant design to the US-APWR design, because both of the plant design is similar, and the process for identification of the change of risk-important HAs can be adapted.

MHI will revise the reference in the DCD 18.3.

Impact on DCD

The first reference of the DCD subsection 18.6 will be revised as follows (changes are underlined);

18.6-1 U.S. Nuclear Regulatory Commission, Guidance for the Review of Changes to Human Actions, NUREG-1764, December 2002.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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DATE OF RAI ISSUE:	**6/8/2010**

QUESTION NO. 18-90

Criterion: In accordance with NUREG-0711, 7.4 (1), the use of PRA/HRA results by the HFE design team should be specifically addressed; that is, how are risk-important HAs addressed (through HSI design, procedural development, and training) under the HFE program to minimize the likelihood of operator error and provide for error detection and recovery capability.

Question:

MUAP 09019P states that issues identified during the HRA/PRA integration evaluation are entered into the HFE tracking system. MUAP 09019 P, Section 2.5 states that HRA/PRA integration evaluation data is recorded in a summary (provided in Appendix 2.10.2. "US-APWR HRA/PRA Evaluation Table"). This form is used to identify HFE design issues to be addressed through the HFE design process, primarily in the Task Analysis and HSI design activities. Issues are addressed in the Human Engineering Deficiencies process.

It is not clear to staff how entering issues identified during HRA into the HED system will allow the HFE program to minimize the likelihood of operator error or provide error detection and recovery capability for these HAs. Staff request more detailed information to explain how HAs will be dealt with once they are entered into the HED system or to explain how HAs will be addressed to minimize the likelihood of operator error and provide error detection and recovery capability.

ANSWER:

The use of the HED system and the process is to assure that a unified basis is applied across all HSI design elements to assure that all issues, including those surrounding risk important human action, are tracked and that the resolution is consistent and compatible across the design. The form in Appendix 2.10.2 is not primarily used to identify HFE issues. The HRA identify risk-important human actions (HA) from the PRA/HRA assumptions such as environmental conditions, HSI design, procedures, training, and supervision. Using operator role considerations the HRA identify significant controls and parameters needed to conduct these risk-important human actions. The HRA provides

critical actions and error assumptions to TA. TA provides detailed task requirements to HRA.

Once HED is identified in the HRA, the HED provide feedback to the following elements on;

- PRA
- TA
- V&V
- Design Implementation
- Human Performance Monitoring

The subject of above HFE elements are described in their specific Implementation Plans. Once they are resolved, historical records will be documented for the records.

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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QUESTION NO. 18-91

Criterion: In accordance with NUREG-0711, 7.4 (1), the use of PRA/HRA results by the HFE design team should be specifically addressed; that is, how are risk-important HAs addressed (through HSI design, procedural development, and training) under the HFE program to minimize the likelihood of operator error and provide for error detection and recovery capability.

Question:

In Section 18.6.2 of the DCD, the applicant states that it identifies PSFs using the guidance found in IEEE Std 1082-1997, Subsection 4.5.2; these guidelines are used to 'optimize the PSF, thereby enhancing the overall human success probability.'

Staff request information on what is meant by 'optimization of PSFs'. Staff request further information to clarify how optimization of PSFs will minimize the likelihood of operator error, provide error detection, and error recovery capability.

ANSWER:

According to NUREG/CR-1278 "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications", which is reference in the report MUAP-07007 and MUAP-09019, performance shaping factors (PSFs) have the most effect on performance in modeling human performance for PRA in such a complex man-machine system as an NPP. PSFs are categorized into three classes: (1) the external PSFs-those outside the individual, (2) the internal PSFs--those that operate within the individual himself, and (3) stressors. If there is a good match between the external PSFs and the internal PSFs, performance of tasks will be more reliable than if there is a mismatch and considered to minimize the likelihood of operator error, provide error detection, and error recovery capability.
IEEE Std 1082-1997 section 4.5.2 provides a general, consensus based, list of a minimum set of PSFs that should be included in an HRA.

Impact on DCD

NUREG/CR-1278 will be added as a reference in the DCD subsection 18.6.5 as follows (changes are underlined);

18.6-4 Swain, A.D. and Guttmann H.E., Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, NUREG/CR-1278, August 1983

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-92

Criterion: In accordance with NUREG-0711, 7.4 (4), HRA assumptions such as decision making and diagnosis strategies for dominant sequences should be validated by walkthrough analyses with personnel with operational experience using a plant-specific control room mockup or simulator. Reviews should be conducted before the final quantification stage of the PRA.

Question:

MUAP 09019 P, Section 2.5 states that HFE design issues to be addresses are identified in the 'comment' section of Table 2.10.2. The Applicant states that identified issues are resolved via the HFE design process, in the Task Analysis and HSI Design elements. HRA assumptions are identified for evaluation in Table 2.10.2 in Section 2.5. Section 2.8 states "HSI basic design, operating procedure and operator training program including staffing assumption shall use those assumptions as their input information."

It is not clear that *all* HRA assumptions for dominant sequences will be identified and validated using the process described in MUAP-09019 P, Section 2.5. Staff request clarification that decision making and diagnosis strategies will be validated by walkthrough.

ANSWER:

MHI will validate all HRA assumptions for dominant sequences identified and validated using the process as described in MUAP-09019-P Part 2 Section 2.5. These reviews will be conducted before the final quantification stage of the PRA as part of the final V&V process.

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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QUESTION NO. 18-93

Criterion: In accordance with NUREG-0711, 7.4 (4), HRA assumptions such as decision making and diagnosis strategies for dominant sequences should be validated by walkthrough analyses with personnel with operational experience using a plant-specific control room mockup or simulator. Reviews should be conducted before the final quantification stage of the PRA.

Question:

MUAP 09019P discusses the use of HRA in the design of US-APWR. Appendices are provided which describe tasks analyzed. Appendix 2.10.1 states that for the low-power and shutdown (LPSD) PRA for the US-APWR DCD, detailed PRA has been carried out only for mid-loop operation state.

The Applicant states that HRA assumptions will be validated via walkthroughs before the final quantification stage of the PRA as part of the V&V process. DCD-0019 implies that the HRA quantification has been performed for the final design. It is not clear to staff when, relative to completion of the V&V process, these reviews will be conducted relative to the final quantification stage of the PRA. Staff request information to clarify when validation of assumptions will be conducted (e.g., during which cycle they will be performed). NUREG-0711, states that reviews of assumptions used in HRA should be conducted prior to the final PRA quantification.

Staff is therefore unclear whether the HRA sensitivity analyses (presented in the Appendix) were run for the JAPANESE standard HSI, for the US BASIC HSI, or for the US APWR HSI design, or for all three iteratively. Staff is further unclear whether identical methods and procedures will be used for later HRA and request clarification.

The applicant is requested to clarify whether the HRA sensitivity analyses (presented in the Appendix) were run for the Japanese standard HIS, for the US BASIC HIS, the USAPWR HSI design, or for all three iteratively.

The applicant is requested to clarify on which design and procedures that HRA analysis will be conducted. If the HRA analysis will be conducted on all three designs or more than one design, please clarify when each will be conducted.

The applicant is requested to provide clarification regarding when HRA assumptions specific to the US APWR design will be validated, as these designs differ in HSI configuration, as well as in type and use of procedures.

ANSWER:

The US-APWR HSI design is iterative and the final design will not be completed until Jan 2011. The final V&V will be conducted in Phase 2 of the US-APWR HFE Process as stated in topical report MUAP-07007. During the Phase 2 V&V, the HRA assumptions will be validated. If the site-specific assumptions of Phase 2 are applicable to the actual site-specific application, then no additional design or V&V is needed. If site- specific assumptions of Phase 2 are not applicable to the actual site-specific application, then a design change process will be conducted as Phase 3.
The HRA sensitivity analyses in technical report MUAP-09019 were run for the US−APWR HSI design as Phase 2a, which is to generate the HFE analysis results necessary to produce the HSI Inventory of the US-APWR.

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

This completes MHI's responses to the NRC's questions.