

  
**MITSUBISHI HEAVY INDUSTRIES, LTD.**  
16-5, KONAN 2-CHOME, MINATO-KU  
TOKYO, JAPAN

June 30<sup>th</sup>, 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-09288

**Subject: MHI's Responses to NRC's 2nd Request for Additional Information on Topical Report MUAP-07007-P(R2), "HSI System Design and HFE Process"**

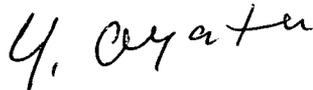
**Reference:** 1) "2<sup>nd</sup> Request for Additional Information for Additional Information on Topical Report MUAP-07007-P(R2), HSI System Design and HFE Process," dated May 1<sup>st</sup>, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to 2<sup>nd</sup> Request for Additional Information for Additional Information on Topical Report MUAP-07007-P(R2), "HSI System Design and HFE Process."

Enclosed is the responses to 56 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,

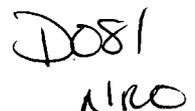


Yoshiki Ogata,  
General Manager- APWR Promoting Department  
Mitsubishi Heavy Industries, LTD.

Enclosure:

1. Responses to 2nd Request for Additional Information on Topical Report MUAP-07007-P (R2), "HSI System Design and HFE Process"

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



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Docket No. 52-021  
MHI Ref: UAP-HF-09288

Enclosure 1

UAP-HF-09288  
Docket No. 52-021

Responses to 2<sup>nd</sup> Request for Additional Information on Topical  
Report MUAP-07007-P(R2), "HSI System Design and HFE Process"

June 2009

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification  
Mitsubishi Heavy Industries  
Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-1**

**Clarify the applicability to operating plants.**

Regarding the topical report's applicability of its description to both US-APWR, a new design, and operating, non-US-APWR plants, MHI states the following on page iv:

This report distinguishes between the descriptions applicable to the US-APWR and those relevant to operating plants, where there is a clear need for such a distinction. Where there are no distinctions, the description is generically applicable to the US-APWR and a broad range of operating plants, although not necessarily all operating plants. When this topical report is referenced in a plant-specific Licensing Amendment Request, the Plant Licensing Documentation will identify any areas of this topical report that are not applicable.

On page 1 MHI states the following:

The design process described in this report is applicable to the MHI Human System Interface [HSI] designs for both new and existing operating plants. The system descriptions are directly applicable to the RAI. For operating plants the basic design features that ensure regulatory compliance are maintained, as described in this report. However, due to plant differences, specific changes in implementation detail will be described in Plant Licensing Documentation...

With respect to the human factors engineering (HFE) process, MHI states the following on page 87:

The applicability to operating plants is dependent on the scope of the HSI upgrade. For operating plant upgrades Plant Licensing Documentation identifies the specific sections of this document that are applied and any deviations from the methods described in this report.

"Plant Licensing Documentation" is defined on page 2 of the topical report as "plant level documentation that is specific to a group of plants or a single plant, such as the

Design Control Document (DCD), Combined Operating Licensing (COL) Application, Final Safety Analysis Report, or License Amendment Request.”

There are two items described specifically for being addressed in the HSI in operating plants. One HSI design item is specifically described by MHI in the HSI design description section as relating to changes to operating plants. In the description of aspects of the design, MHI indicates that the sizes and locations of the large display panel’s screen may vary in operating plants based on physical limitations of the operating plant. Staffing and qualification requirements results are described in HFE process section. The described “minimum and maximum staffing” (minimum operating staff located in and outside the MCR; maximum operating staff located in the main control room (MCR)) “may ... be applied to operating plants with an appropriate level of plant modernization. Staffing and analysis for modernized operating plants is described in Plant Licensing Documentation.”

The wording in topical report sentences quoted above, “For operating plants the basic design features that ensure regulatory compliance are maintained, as described in this report.” and “The applicability to operating plants is dependent on the scope of the HSI upgrade.” makes it unclear what aspects of the HFE process and the HSI system design described in this report apply to operating plants. It is unclear what might differ “basic design features” from those that are not “basic design features.” The second sentence leaves the specification of the applicability of the topical report’s HFE process and HSI system design description completely indeterminate. Please provide clarity on the applicability of the topical report to operating plants.

**MHI Response:**

Based on the following statements, all sections of this topical report are applicable to operating plants:

Section 1.0 - “The purpose of this Topical Report is to describe the Mitsubishi Heavy Industries (MHI) Human System Interface (HSI) System (HSIS) design and the Human Factors Engineering (HFE) design process used by MHI for that system. MHI seeks approval from the US Nuclear Regulatory Commission for the use of the MHI HSI System for new nuclear plants and for operating nuclear plants.”

Abstract - “When this topical report is referenced in a plant-specific Licensing Amendment Request, the Plant Licensing Documentation will identify any areas of this topical report that are not applicable.

This topical report describes the Basic HSI System design, and the HFE design process. Both are applicable to new and operating plants. Within the design process section, this document defines the “Plant Licensing Documentation” that MHI will generate for either application. The “Plant Licensing Documentation” that has been generated, and will continue to be generated, for the US-APWR exemplifies the “Plant Licensing Documentation” that will be generated for operating plants.

For example, for the US-APWR, the “Plant Licensing Documentation” is fulfilled by the US-APWR DCD and the ITAACs. The DCD contains the US-APWR plant specific plans for each HFE Program Element. In addition, the DCD references HFE reports that will be submitted for NRC review during the DCD review process. The ITAACs in Tier 1 define the plant specific HFE reports that will be available for NRC review later in the licensing process. It is noted that for the US-APWR, there are very few site

specific HFE activities. Therefore, most "Plant Licensing Documentation" is generically applicable to all sites. Site specific "Plant Licensing Documentation" is defined as COL actions, and is described in the COLA. Therefore, the words "Plant Licensing Documentation", as used in the TR, or "plant specific" as used in many RAI responses, do not refer to documentation in a specific COL Application, but rather to documentation in the US-APWR DCD or associated generic US-APWR ITAAC reports.

For an operating plant upgrade, MHI plans to use a similar approach. A license amendment request (LAR) would define all plant specific HFE program element plans to a level of detail that is comparable to Chapter 18 of the US-APWR DCD. The scope of each HFE program element plan would be tailored to reflect the extent of change from the current plant condition, and any changes from the generically approved HSI System design, if any. The LAR would also include the schedule for generating all of the plant specific HFE reports, required by this HSI Topical Report (MUAP-07007).

**FOLLOW-UP RAI:**

MHI's response does not provide the information requested by the staff.

The RAI states that it is unclear in the Topical Report what distinguishes "basic design features" from those design features that are not "basic". The response to the RAI introduces the statement that the "topical report describes the Basic HSI System design," which does not adequately address the RAI. Please provide detailed clarifying information describing those parts of the HSI system design that are "basic," from those that are not. In addition, please provide detailed clarifying information describing which design features "ensure regulatory compliance."

It is unclear to the staff what the word "maintained" in the sentence "For operating plants the basic design features that ensure regulatory compliance are maintained, as described in this report." means. Please clarify the meaning of the word "maintained" within the context of the statement.

To assist the staff in understanding those aspects of the HSI design that shall be applicable to operating plants apart from those that are not, the staff requests that MHI:

- clarify what is meant by the term "basic design features" with enough specificity so that the definition can be used to systematically distinguish basic design features from those that are not,
- indicate specific design features as being basic or not basic, or
- revise the wording of the topical report to clearly indicate which design features will be applicable to operating plants.

Also, the distinction between "plant specific" and "site specific" in the response is difficult to understand. A common interpretation of "plant specific" items are those items that are particular to an individual plant, and "site specific" items are those items that are particular to an individual site (which could include more than one plant). It is unclear why "plant specific" items are addressed in more generically applicable licensing documents than "site specific" items. The text in the response to RAI 18.0-2 states that "the HSI design for local controls and HFE design process for local controls is plant specific and is therefore not included as part of the generic HSI System design or design process description," suggests that "plant specific" items are not included in more generically applicable licensing documents – this appears to be inconsistent with the response to the current RAI. Please clarify the usage of "plant specific."

**ANSWER:**

The following table and description will be added to Appendix D of the Tropical Report to clarify the scope and features of the “Basic HSI System” vs. a “Plant Specific HSI System” , and to clarify the distinction between “plant specific” and “site specific”:The HSI System described in this Topical Report is referred to as the Basic HSI System. The table below identifies the “Scope of the Basic HSI System” and how it is applied to specific plants to become a “Plant Specific HSI System”. The column labeled “Plant Specific HSI System” reflects the systems (mechanical, electrical and I&C), safety analysis, D3 coping analysis and HFE analysis, for each plant. These analyses are reassessed for each plant even though the analyses may be very similar among different plant types.

Within this context “Plant” refers to a specific nuclear unit or a family of units that share the same design. For example, the US-APWR is a plant, as is System 80 and SNUPPS. When “Plant” refers to a family of units that share the same design, there are site specific variations, such as interconnections to the grid and to the ultimate heat sink. HFE analysis is a Phase 2 activity for each plant. For plant families, site specific variations are accommodated in Phase 3. These Phases of the HFE program are described in Appendix C of this Topical Report.

MUAP-07007 Section	Scope of the Basic HSI System	Plant Specific HSI System
4.1 Design Basis	Use of soft touch controls, and displays based on computer processed data. Standardized visual coding.	None
a. Integration of monitoring and operation	Methods of integrating multi-channel data and controls. Areas where multi-channel HSI is utilized.	None
b. automatic verification of component status	Automated checking method, display and alarm method (icons and behavior, display on LDP with drill-down displays). Applies to all functions automatically initiated by the RPS and ESFAS, and all system level safety related interlocks.	Specific safety functions, interlocks, components and their acceptable states.
c. Inter-linked screen request	Navigation methods and selection options (procedures, alarms, graphics, controls).	Specific linked screens.
d. Use of Large Display Panel for situation awareness and information sharing	Information selection criteria (critical power and safety functions, and their success paths) and display method (icons and behavior).	Critical safety functions and success paths differ between NSSS vendors. Success paths vary for power production functions based on BOP design.
e. Alarm prioritization system	Alarm processing method, prioritization method, display and acknowledgement method.	Specific alarm conditions.
f. Main Control Room Staff	Minimum and maximum number of operators.	Actual number of operators for each operating crew
g. Applicable plant personnel	Basic HSI addresses the needs of operations staff only.	HSI needs of non-operating personnel is outside the scope of the Basic HSI.
4.2 HSI System Facilities	HFE design process encompasses all facilities identified. However, Basic HSI design is used only at MCR, RSR and TSC.	HSI design for EOF and local stations..
4.2.1 Main Control Room	Content of physical work areas, HSI devices and layout of consoles, design basis for MCR fire propagation.	Actual console and work area arrangements are based on architectural constraints.
4.2.2 Remote Shutdown Room	Design basis, HSI devices and layout of console, transfer design.	Actual console arrangement is based on architectural constraints.
4.2.3 Technical Support Center	Content of physical work areas. HSI detailed design and content is same as MCR.	HSI devices and layout of consoles. Actual console and work area arrangements are based on architectural constraints.
4.2.4 Interface with Emergency Operation Facility	HSI inventory is received from SPDS. SPDS design basis and information content is part of Basic HSI design.	Detailed HSI implementation design is unique for each plant. EOF implementation detail is the licensee's responsibility.
4.2.5 Local Control	None	HSI design is unique for each plant.
4.3 Layout Design	General arrangement and maximum	Actual console and work area

<b>MUAP-07007 Section</b>	<b>Scope of the Basic HSI System</b>	<b>Plant Specific HSI System</b>
4.3.1 Main Control Room Layout (including subsection a-c)	distance between consoles. Minimum LDP character size.	arrangements are based on architectural constraints.
4.3.2 Operator Console Layout	Number and arrangement of VDUs at each console. Location of Class 1E switches for system level actuation of safety functions. Design basis of LDP, Operational VDUs, Safety VDUs, diverse HSI. LDP size.	Specific safety function switches and diverse HSI devices. LDP size is addressed in 4.9.2.
4.4 Display Overview and Navigation	Purpose of each VDU type.	None
4.4.1 Display Overview		
4.4.2 Display Navigation System	Display hierarchy, and vertical and horizontal navigation method within the hierarchy. Features and style guide for navigation touch controls.	Specific navigational links on Operational VDUs and Procedure VDUs.
a. Operational VDU		
b. Safety VDU		
c. Alarm display navigation		
d. Operating procedure display navigation		
4.5 Operational VDU Display Design	Display type and approximate screen size.	Actual screen size based on technology evolution and availability.
4.5.1 Operation Devices		
4.5.2 Operation Method	Method of navigating to pop-up control windows. Ability to relocate pop-up control windows.	None
a. Calling Up Switches		
b. Controller and Mode Selector	Design basis and content for displays with fixed controls. Available functions for modulating controls.	Design of specific displays with fixed controls, and the grouping of fixed controls set based on the phase 1 results is verified using task analysis.
c. Displaying Screens Related to Soft Operations	Style guide for soft controls.	None
4.5.3 Switch Features	Features and layout of discrete control window. Tag-out method and displays.	None
a. ON/OFF Switches Operation Related Information Display Feature		
b. Manual Operation of controller Information Display Feature	Features and layout of modulating control window.	None
c. Provisions to Prevent Erroneous Operation	Control access and activation features. Operation of cascaded controls.	Specific functions that utilize cascaded controls
4.6 Safety VDU Display Design	Display type and approximate screen size.	Actual screen size based on technology evolution and availability.
4.6.1 Operable Devices		
4.6.2 Operational VDUs Connect/Disconnect	Interlock description for control of safety components from Operational VDUs.	None
4.6.3 Monitor Screen	Navigation method, layout and content of monitoring screens	Specific menus and displayed parameters.
c. Operation Screen	Navigation method, layout and content of control screens.	Specific menus and displayed components.
4.7 Alarm System	Design basis.	
4.7.1 Alarm Display System	Alarm display locations, categorization, acknowledgment states and icon behavior.	None
a. Display Location		
b. Allocation of roles between the Alarm VDU and the Large Display Panel	Correlation between alarms on LDP and alarm VDU. Navigation methods, acknowledgement methods, design and behavior of displays for dynamically prioritized alarms.	Specific alarm conditions.
4.7.2 Alarm Prioritization	Static prioritization categories.	Static prioritization category for each alarm.
c. Prioritization Based on Specific Importance (Static Prioritization)		
d. Prioritization Based on Dynamic Prioritization (Dynamic Prioritization)	Categories and rules for dynamic alarm prioritization.	Initial category, dynamic logic and associations, and resulting category for each alarm.
4.7.3 Coding by Alarm Sound	Sound coding for first out alarms, dynamic prioritization categories, bypasses and permissives.	None
4.7.4 First-out Alarms Displaying	Trigger categories, display locations, time sequenced display.	Specific trigger conditions.
4.7.5 Acknowledging and	Alarm control functions and locations for	None

<b>MUAP-07007 Section</b>	<b>Scope of the Basic HSI System</b>	<b>Plant Specific HSI System</b>
Resetting Alarms & Stopping Alarm Sound	acknowledgement and sounds.	
4.7.6 Avoiding Nuisance Alarms	Design basis of logic to distinguish normal vs. alarm conditions.	Actual alarm distinction logic.
4.7.7 Link to Related Display	Navigational links from alarms on alarm VDU to displays on Operational VDU and procedures on Procedure VDU	Specific linked displays and procedures are defined for each alarm.
4.8 Computer-Based Operating Procedure	Screen layout, style guide, navigation and paging controls, hyperlink controls, place keeping controls. Paper to electronic conversion method and configuration control.	Specific procedures.
4.9 Large Display Panel 4.9.1 Purpose of Large Display Panel Installation	Goals of LDP	None
4.9.2 Large Display Panel Screen Display Features	None	Screen size is adjusted to accommodate architectural constraints. For example, smaller screens may be used and duplicated, as necessary.
4.9.2.1 Fixed Display Area	Design basis for different plant conditions.	Specific indications and alarms vary based on safety functions and success paths. Table 4.9-1 is typical.
4.9.2.2 Variable Display Area	Design basis for automatic display presentation. Controls for manual display selection.	Specific conditions that activate automatic display presentation.
4.9.3 Alarm Display on the Large Display Panel a. Flow Sheet Image b. Abbreviation of Alarm Name	Style guide for LDP component and icons and related alarms.	Specific components represented.
c. Message Slot System	Style guide for LDP process parameters and related alarms.	Specific parameters represented.
d. First-out Alarm	Alarm categories and display method	Specific alarms within each category.
e. Shared Alarms	Prioritization display and behavior for grouped alarm icons.	Grouped alarm icons and the specific alarms within each group.
f. SDCV Alarms and BISI status	Design basis categories.	Specific alarms within each category.
4.10 Automatic Checking of Actuators 4.10.1 Integration of Monitoring and Operation	Design basis for component status monitoring.	Specific components monitored.
4.10.2 Automatic Checking of Actuators for Events	Design basis and method for automatic checking of automatic safety function actuators.	Specific functions and specific components within each function, to correspond with EOPs.
4.10.3 Automatic Verification of Critical Safety Functions	Design basis and method for automatic checking of critical safety function status.	Specific functions and specific parameters and logic within each function, to correspond with EOPs.
4.11 Response to HSI Equipment Failures	Design basis for normal and degraded HSI conditions.	None
4.11.1 Standard Configuration	Design basis for normal HSI conditions. Operation is confirmed during Phase 1 V&V activities.	Operation is confirmed during Phase 2/3 V&V activities.
4.11.2 Degraded HSI Systems by a Single Failure	LDP failure and contingency conditions. Workstation VDU failure conditions. Operation is confirmed during Phase 1 V&V activities.	Operation is confirmed during Phase 2/3 V&V activities.
4.11.3 Loss of All Non-safety HSI	HSI for continued operation. Operation is confirmed during Phase 1 V&V activities.	Operation is confirmed during Phase 2/3 V&V activities.
4.11.4 Loss of All Digital Non-safety and Safety HSI (CCF)	HSI for coping with accident conditions. Operation is confirmed during Phase 1 V&V activities.	Operation is confirmed during Phase 2/3 V&V activities.
4.11.5 Loss of MCR	HSI for coping with conditions that require MCR evacuation. V&V conducted for 4.11.3 bounds this condition.	V&V activities are limited to location and actuation of MCR/RSR transfer switches.
4.12 Key Technical Issues a. Multi-channel operator stations	Design basis for multi-channel Operational VDUs and backup channelized Safety VDUs.	Specific information and controls on each display.
b. HSI to accommodate reduced operator staffing	Design basis for HSI features that facilitate minimum operator staffing.	None
c. Operation under	See 4.11, above.	See 4.11, above.

MUAP-07007 Section	Scope of the Basic HSI System	Plant Specific HSI System
Degraded Conditions		
d. Minimum inventory of HSI	Minimum inventory is defined for SDCV HSI and HSI to accommodate degraded HSI conditions. Class 1E HSI is provided for all Class 1E instrumentation and plant components.	Specific inventory within each design basis category.
e. Computer based procedures	Design basis and quality program.	Specific procedures are developed under the plant quality program.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**QUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.: 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2**

**SRP SECTION: 18 – Human Factors Engineering**

**APPLICATION SECTION: 18.0**

**DATE OF RAI ISSUE: 5/01/2009**

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**Follow-up RAI to RAI NO. : 18.0-3**

**Clarification of HFE program goals**

HFE program goals are discussed in Section 5.1.1.1 and are an almost exact restatement of NUREG-0711, "Human Factors Engineering Program Review Model," Rev. 2 criteria 2.4.1(1). These are generic goals that would be expected of well-designed systems. MHI should show a plan for how these goals will be further defined into objectives that are testable or able to be evaluated and how achievement of these objectives will be tested and/or evaluated. What is the plan for how the HFE activities will meet the HFE Program Goals, how will the HFE Program Goals be further defined into testable or verifiable objectives, and how will achievement of these objectives be tested and/or evaluated?

**MHI Response:**

Section 5.1 provides an overview of the HFE Program Plan. Each element of the plan is described in sections 5.2 through 5.12. Each section describes the objectives of that specific element and how those objectives are accomplished.

Section 5.10 describes the Human Factors Verification and Validation plan. This section describes how the HFE program goals are further defined into testable or verifiable objectives and how those objectives are evaluated. As stated in Section 5.0 "This section describes the generic HFE design process. Any portions of the HFE design process that are not complete for a specific plant and therefore may require future commitments, such as Design Acceptance Criteria or licensing conditions for operating plants, are described in Plant Licensing Documentation."

The Topical Report is intended only to describe the key aspects of the program plan for each HFE program element. The detailed HFE program plan and the schedule for executing that program plan are described in Plant Licensing Documentation. Chapter 18 of the DCD for the US-APWR provides that detailed program plan for the US-APWR, and therefore exemplifies this approach. Attachment-1 shows MHI's planned schedule for generating all reports for the US-APWR HFE program.

**Follow-up RAI:**

MHI's response does not address the information requested by the RAI. Also, the US-APWR DCD document does not give sufficient detail to sufficiently address the criterion in NUREG-0711, section 2.4.1(1). Please provide:

1. The generic HFE program goals of the program
2. The plan for **how** these goals will be further defined into objectives that are testable or able to be evaluated
3. **How** achievement of the objectives will be tested and/or evaluated.

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**ANSWER:**

The following description of the generic HFE program goal is added in section 5.1.1.

“The generic HFE program goals of the program are as follows;

- i) Ensures HFE program is implemented in conjunction with plant design process.  
Appendix C, HSI/HFE topical report show the HFE program will be completed in conjunction with plant design process which will be completed by the plant construction and operation milestone.
- ii) Ensures that the integrated HSI and support functions/ implementation program, i.e., operating procedures, staffing/qualifications, training show high degree of operating crew situation awareness.  
Operating crew situation awareness will be verified and validated in V&V process and HEDs which addresses situation awareness issue, will be addressed and resolutions are feedback to HSI design and/or supporting functions/programs in order to improve them. Then this iteration process will continue until the situation awareness level reaches more than the current situation awareness level of operating HSI in the U.S. and Japan, using Likert measurement methodology.
- iii) The plant design and allocation of functions always provide operation vigilance and acceptable workload levels.  
Functional requirement analysis and Functional allocation address operator's significant monitoring parameters and controls and task analysis ensures the estimated staffing conduct operation within acceptable workload which is defined as comparison with the current workload level.
- iv) The HSI and supporting functions/programs minimize operator error and provide for error detection and recovery capability.  
Human Reliability Analysis addresses critical human actions for establishing plant safety and how they are considered through HSI design and supporting functions/programs.”

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** 2<sup>nd</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-6**

**Detail on involvement of plant personnel in plant modifications.**

Though MHI seeks NRC approval of the topical report for replacement of current HSI systems in operating plants, the topical report does not discuss the part of this criterion that addresses plant modifications. Please provide detail on how plant personnel will be involved in the HFE program for plant modifications.

**MHI Response:**

As stated in the response to RAI 18.0-04, MHI plans to engage US utility operators in each element of the US HSI System development. This is applicable to new plants or operating plant modifications. The detailed plan for the HFE program for a plant modification will be described in plant licensing documentation.

The following will be added to Section 5.11: "Facility design changes are documented and analyzed for their potential impact on HSIs. Those design implementation issues that negatively impact human performance are identified as HEDs and are tracked and dispositioned. HFE design modifications are documented in a periodic status report."

**Follow-up RAI:**

The RAI asks for detail on how plant personnel will be used in the HFE program for plant modifications. MHI states in the response to RAI 18.0-1 that "The detailed plan for the HFE program for a plant modification will be described in plant licensing documentation." Please provide clarification on what this statement means.

Is the HFE program plan for plant modifications described in the Topical Report a general version of a HFE program plan described in other licensing documentation? Please provide clarification on the relationship between the HFE program plan described in this document and detailed program plans for plant modifications that will be described in other licensing documentation.

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**ANSWER:**

The following will be added to Section 5.0:

"The HFE program plan described in this section is a general version of an HFE program plan which can be applied for new plants as well as plant modifications. The plant licensing documentation for each project provides an individual HFE program plan which can accommodate each project integrating some citation of the general portion of a HFE program plan in the Topical Report and specific information considering each project condition. Chapter 18 of the US-APWR DCD exemplifies a plant specific program plan, which fulfills the requirement for "plant licensing documentation". This plan is followed by an Overall HFE Implementation Procedure and specific Implementation Procedures for each program element, all written uniquely for each project. A similar set of plan and procedure documents will be written for each plant modification project."

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification  
Mitsubishi Heavy Industries  
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**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-7**

**Detail on effects of modifications on personnel performance.**

Even though MHI seeks NRC approval for replacement of current HSI systems in operating plants, this document does not address the criteria for Effect of Modifications on Personnel Performance. For replacements of current HSI systems in operating plants with the US-APWR HSI, please provide detail how the HFE program plan address the effects of these modifications on personnel performance.

**MHI Response:**

HFE program elements 2 thru 6 consider the Effect of Modifications on Personnel performance. The goal of each element is to ensure the HSI design maintains or improves current human performance levels. This is confirmed initially through HFE program element 10 and then throughout the life of the plant in HFE program element 12. Program element 6 specifically identifies risk significant tasks and activities conducted in each HFE program element to minimize the potential for human performance errors. As stated in Section 5.11 "For any HSI change to a licensed design the potential impact on Human Actions is assessed and a risk significance level is assigned in accordance with the criteria in NUREG-1764. The risk significance considers the scope of the change as well as the potential impact on plant safety functions." The detailed HFE plan for plant specific HSI modifications will be described in plant licensing documentation. In general, the HFE plan for any plant HSI upgrade would be comparable to Chapter 18 of the US-APWR DCD. However, each HFE Plan would be tailored to the modification, with focus on what is actually changing. For example, if we are simply changing the HSI but there are no changes to Function Allocation, there would be a minimal effort (and plan description) for the FRA/FA program element.

**Follow-up RAI:**

NUREG-0711 Rev. 2 cites documents that give guidance for evaluating modifications to plants, specifically R.G. 1.187 and NEI 96-07. NEI 96-07 contains the methodologies that are acceptable to the staff for complying with the provisions of 10 CFR 50.59, which addresses plant modifications. There is not enough detail provided to assess whether or not MHI's HFE program plan is consistent with the guidance

given by NEI 96-07. Please provide enough detail so the staff can verify that MHI's resulting HFE program plan for the effects of modifications on personnel performance will conform to the intent of the methodology.

Also, please provide clarification as to what "comparable to" means in the sentence "In general, the HFE plan for any plant HSI upgrade would be comparable to Chapter 18 of the US-APWR DCD."?

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**ANSWER:**

"Comparable" means that a program plan for a plant specific upgrade would address all HFE program elements defined by NUREG-0711, using the methodology defined by the Topical Report. This plant specific program plan is the "plant licensing documentation" for that upgrade. Since the plant specific HFE program plan will address each of the HFE program elements defined by NUREG-0711, the HFE program includes a thorough safety assessment, which provides the input information necessary to implement the methodology of NEI 96-07.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-8**

**Clarification of HFE team responsibilities.**

In Section 5.1.2.2, MHI addresses responsibilities of the HFE team by describing the HFE team roles. There is no discussion of the HFE team's responsibility for developing the HFE plans and procedures or review of HFE activities. Please provide a discussion of the HFE team's responsibility for developing the HFE plans and procedures or review of HFE activities.

MHI states that the Project Manager is responsible for making sure aspects of the HFE activity follow the HFE Implementation Plan. MHI states that the Design Team Manager is responsible for "phasing of activities." It is unclear what "phasing of activities" includes -- does "phasing" include scheduling the activities and milestones? Also, since there is a separate V&V Team Manager it is unclear if the Design Team Manager is responsible for scheduling of verification and validation (V&V) -- both seem to report to the Project Manager, but not to each other. Please clarify the intent of "phasing of activities."

The team described is called the "HFE Design Team." However, there is no discussion of who is responsible for carrying out the operating experience review, the functional requirements and function allocation analysis, the task analysis, the staffing and qualifications analysis, the human reliability analysis, procedure development, the training program development, the design implementation, or human performance monitoring. It is unclear if the HFE team will be responsible for developing HFE plans and procedures, reviewing HFE activities, and scheduling all HFE activities and milestones. Please clarify the HFE team's responsibilities with respect to the development of all HFE plans and procedures; oversight and review of all HFE design, development, test, and evaluation activities; and scheduling of activities and milestones.

**MHI Response:**

The following will be added to the responsibility of the HFE Design Team Manager: "Development of HFE plans and procedures, conducting HFE activities for all elements except Verification and Validation (V&V), and review of V&V results."

The following will be added to the responsibility of the HFE V&V Team Manager: "Development of HFE plans and procedures for V&V. Review of HFE plans, procedures and results for all elements except V&V."

The following will be added to Section 5.1.2.2: "The Design Team Manager's responsibility of "phasing of activities" includes planning the schedule for all HFE activities and milestones, including the high level scheduling of V&V activities and milestones. However, the detailed scheduling of V&V activities and milestones is the responsibility of the V&V Team manager."

The following will be added to Section 5.1.2.2: "The HFE Design Team is directly responsible for developing plans, procedures and schedules, and carrying out the HFE activities for the operating experience review, the functional requirements and function allocation analysis, and the task analysis. The HFE Design Team reviews the plans, procedures and schedules, and provides oversight for the staffing and qualifications analysis, the human reliability analysis, procedure development, V&V, the training program development, the design implementation, and human performance monitoring".

**Follow-up RAI:**

MHI's response gives a general description of the HFE Teams responsibilities. However, it does not detail **how** the HFE team goes about carrying out those responsibilities which are the staffing and qualifications analysis, the human reliability analysis, procedure development, V&V, the training program development, the design implementation, and human performance monitoring. The response seems to be a restatement of the NUREG-0711 criterion. Please provide detailed clarifying information so that the staff can assess how the HFE Team carries out the various activities highlighted in the NUREG-0711 Section 2.4.2 criterion 1.

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**ANSWER:**

The following will be added to Section 5.1.2.2:

"Each project includes an Overall HFE Implementation Procedure and specific Implementation Procedures for each program element. These procedures detail the responsibilities of the HFE Design Team and V&V Team, including how those teams carry out their responsibilities for each program element."

The US-APWR Technical Report to be submitted in the end of June will provide the overall HFE implementation procedure and implementation procedures for FRA/FA, HRA and TA. These procedures exemplify this documentation process for all remaining US-APWR implementation procedures (for the remaining HFE program elements), and for other plants.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-9**

**Clarification of the HFE team's organizational placement and authority.**

The HFE team's organizational placement and authority is described in Section 5.1.2 of the topical report. However, there is no description of how the HFE team relates to the organization of the US-APWR's total program and its authority within the US-APWR's total program. Other than MHI's statement that the HFE V&V Team Manager has the "authorities to ensure V&V activities are not adversely affected by commercial and schedule pressures" there is no further discussion of the HFE Team's authority to assure that its responsibilities are accomplished, to identify problems in overall plant design implementation, or to control processing, delivery, installation, of use of HFE products when a problem has been identified. How does the HFE Team relate to the organization of the US-APWR's total program and what is its authority within the total program? What is the HFE Team's authority to assure that its responsibilities are accomplished, to identify problems in overall plant design implementation, and to control processing, delivery, installation, of use of HFE products when a problem has been identified?

**MHI Response:**

The HFE Design Team is one of the engineering branches in the US-APWR project organization and responsibility for HFE aspect of the US-APWR total program.

The HFE Design Team is responsible for identifying HFE problems in overall plant design implementation, controlling HFE processing, delivery, installation, of use of HFE products. Section 5.1.3 describes the "The process through which the HFE Design team executes its responsibilities..." The placement of the HFE Design Team Manager within the overall organization is defined in the HFE Program Implementation Procedure, which is a plant specific document."

The plant specific documentation for the US-APWR is the HFE Program Implementation Procedure, described in Section 18.1.3.1 of the DCD. This procedure governs all generic US-APWR HFE activities (i.e., those activities covered by the DAC/ITAAC). This procedure will be in place for all US-APWR HFE activities (i.e., OER, FRA/FA, HRA, TA, etc). In addition, this procedure governs how the HFE Team interacts with other design organizations for the US-APWR.

For the few site specific HFE Program activities, the COL applicant will either adopt the same HFE Program Implementation Procedures or write their own.

**Follow-up RAI:**

MHI's response simply indicates that this is a plant specific issue; the DCD section referred to indicates the generic responsibilities, but the issue of authority to assure appropriate HFE is not addressed. Please give clarifying detailed information on what the HFE Team's authority is to assure that its responsibilities are accomplished, to identify problems in overall plant design implementation, and to control processing, delivery, installation, of use of HFE products when problems have been identified.

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**ANSWER:**

The following will be added to Section 5.1.2:

“For each new plant or operating plant upgrade project, the following will be included in the project Quality Assurance Manual:

New or revised documents that describe or impact human actions regarding operations, maintenance or test activities of safety significance, shall be reviewed by the HFE Team. Comments from the HFE Team should be mutually resolved prior to issuance of the document. Where this is not possible, the comments shall be tracked for resolution in the HFE Issues Tracking System. Comments that cannot be resolved shall be elevated through the management chain for resolution.”

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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**Follow-up RAI to RAI NO. : 18.0-10**

**Clarification on responsibilities, qualifications, and credentials for HFE team positions.**

The HFE Design Team's composition is described in Section 5.1.2.2 of the topical report. While MHI states that the Design Team Manager is responsible for "phasing of activities" it is unclear if the Design Team Manager or anyone else will have the specific responsibility of developing and maintaining the HFE design process schedule. Other typical contributions of the Technical Project Management functions include being a central point of contact for management of the HFE design and implementation process – MHI does not discuss who is responsible for this function.

Also, there is no discussion of the qualifications or credentials for positions within the HFE Design Team.

Please provide explanation for who is responsible for developing and maintaining the HFE design process schedule, who is the central contact for management of the HFE design and implementation process, and the qualifications and credentials for positions within the HFE Design Team.

**MHI Response:**

The following will be added to Section 5.1.2.2: "The Design Team Manager is responsible for developing and maintaining the HFE design process schedule. The Design Team Manager is the central point of contact for management of the HFE design and implementation process".

The technical skills encompassed by the aggregate of all HSI Design Team Members are described in Section 5.1.2.2 2).

The following will be added to Section 5.1.2.2 2): "The HFE design team conducts all design activities for HSIs. The HFE design team consists of a multi-disciplinary technical staff. The team is under the leadership of an individual experienced in the management of the design and operation of complex control technologies. The specific individuals and qualifications of those individuals, who are responsible for

each HFE program element, are documented within the implementation procedure for that HFE program element.”

**Follow-up RAI:**

Qualifications and credentials (per NUREG-0711, Appendix A) for the technical staff in various skill areas are not addressed.

Experts on each program element do not necessarily correlate to the HFE team members. If there is correlation it needs be stated explicitly so there is a basis for describing the qualifications and credentials within individual sections of the implementing procedure.

Please provide the necessary qualifications and credentials for the HFE design team's technical staff.

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**ANSWER:**

The following will be added to Section 5.1.2.2:

“As a minimum, the HFE team for each program element will include one or more experts with skills in HF engineering, plant operations, program management and database management. In addition, the following additional experts will be included for each specific program element:

- OER – I&C
- FRA/FA – plant systems
- TA –plant systems
- Staffing and Qualifications – plant maintenance
- HRA – PRA
- HSI Design – I&C, plant systems
- Procedures – procedure
- Training – training
- V&V – training and procedure
- Design Implementation – I&C
- Human Performance Monitoring – training”

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-11**

**Clarification on team staffing.**

Except for the Project Manager, the HFE Design Team Manager, and the HFE V&V Team Manager, there is no discussion of the job descriptions or assignments of HFE team personnel. Please provide detail on the job descriptions and assignments of the complete HFE team.

**MHI Response:**

The job descriptions of the HFE Design Team and V&V Team personnel are encompassed in the descriptions of the HFE program elements. Specific job assignments are the responsibility of the Design Team and V&V Team managers. These assignments change frequently and are therefore not appropriate for licensing documentation.

**Follow-up RAI:**

What skills with members of the HFE Team have and how will the HFE Team members employ these skills for the various tasks performed for design, evaluation, issue tracking, work scheduling, etc. More detail is necessary describing the specific job activities in the program elements and what category of personnel (HF engineer, nuclear engineer) etc will be performing that function. Also, see Supplemental RAI 18.0-10.

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**ANSWER:**

The specific skills required for each program element are described in the response to RAI 18-10. The specific Implementation Procedure for each program element describes the various tasks for that program element.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-12**

**Clarification of general process procedures.**

The general process procedures are described in Section 5.1.3.a. MHI makes reference to a flow diagram (Figure 5.1-2) that illustrates the general process procedures, but there is little detail provided to explain the process flow diagram. There is very little detail explaining general process procedures particulars in the text. There is no discussion of what the "Design Section" or the "Review Section" is. There is no discussion of the sheets, logs, and documents in the figure. There is no description of what the responsibilities of the Review Manager are and what the relationship between the HFE Team and the Review Manager is. There is no description of what the responsibilities of Open Review Committee are and what the relationship between the HFE Team and the Open Review Committee is. Please provide detail, to address the deficiencies identified, on the procedures for assigning HFE activities to individual team members, governing the internal management of the team, making management decisions regarding HFE, making HFE design decisions, governing equipment design changes, and design team review of HFE products.

**MHI Response:**

Figure 5.1-2 will be revised, as follows;

“Review Manager” will be replaced with “HFE V&V Team Manager”

“Review Section” will be replaced with “HFE V&V Team”

“Review Committee Member” will be replaced with “HFE V&V Team Member”.

Text will be added to generally explain the interaction of the HFE review process with the rest of the plant, as follows:

An HFE Design Team representative will be assigned to review every plant document that contains requirements or descriptions of safety significant human-machine interfaces. This includes documentation for local controls, maintenance activities, periodic testing activities, etc. HEDs identified by the HFE Design Team reviewer will be entered in the HFE Issues Tracking System database and tracked to closure.

The details of this interaction process are included in the HFE Program Implementation procedure.

**Follow-up RAI:**

The details requested are summarized in a two sentence paragraph, which the response states will be elaborated in a program implementation procedure. The adequacy of a process cannot be evaluated without details on how the general HFE process works. Please provide these details for staff review.

---

**ANSWER:**

The following will be added to section 5.1.3a:

The process through which the HFE Design team executes its responsibilities is depicted in Figure 5.1-2. In this figure, the "Design Section" refers to another organization (not the HFE team) responsible for generating a document that contains requirements or descriptions of safety significant human-machine interfaces. The "Review Committee" refers to the aggregate of all reviewers for that document; an HFE team member is one of the reviewers. "Review record sheets" and "Record Review Log" are used to formally document and track the reviewers' comments. Comments that result in unresolved HFE issues are extracted and tracked in HFE Issues Tracking system. These issues are closed only after the resolution is reflected in the appropriate HSI documentation (e.g., HSI design, procedures, training).

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-17**

**Clarification of HFE requirements for sub contractors.**

Subcontractor HFE efforts are described in Section 5.1.3.f. MHI states that HFE requirements are included in each subcontract and that "HFE requirements are periodically verified by review of the subcontractor's HMI design and manufacturing guidelines by the HFE Team." There is no detail on the verification process of subcontractor HFE efforts – what are the criteria for determining if a subcontractor is compliant with HFE requirements?

**MHI Response:**

The following will be added to Section 5.1.3.f: "The V&V Team is responsible for this verification review. Verification will be conducted to the same standards as designs created by the Design Team. For example if the supplier is intended to conform to the Basic HSI System Style Guide, the V&V Team will verify the supplier's products against the Style Guide. Verification procedures are plant specific documents".

**Follow-up RAI:**

Is the V&V team involved in verifying supplier products at the design stage?

How are Design Team standards determined?

How are the Design Team standards communicated to the V&V team?

In the response, please clarify what "is intended to" mean in the sentence "For example if the supplier is intended to conform to the Basic HSI System Style Guide, the V&V Team will verify the supplier's products against the Style Guide."?

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**ANSWER:**

To address the Staff's questions, Section 5.1.3 (f) will be modified as follows:

The V&V Team is responsible for this verification review. Verification will be conducted to the same standards as designs created by the Design Team. For example if the supplier is required to conform to the Basic HSI System Style Guide, which the V&V Team has already verified against NUREG-0700, the V&V Team will verify the supplier's products against the Style Guide. Otherwise, the V&V Team will verify the supplier's products against NUREG-0700. In all cases, the HSI inventory provided by the supplier will be verified against the operating/maintenance/test procedures and/or the task analysis. Verification procedures are plant specific documents. These procedures define the standards and input documents to which the supplier's design will be verified. These verification activities occur during the design stage.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-18**

**Clarification of HFE issues tracking system.**

Little detail is given on the HFE Issues Tracking System other than it is the same system as that is used for the rest of the US-APWR design effort -- no description is given of this system. Please describe the tracking system including how it will help provide reasonable assurance that HFE issues that need to be addressed before the design process is completed are not overlooked.

**MHI Response:**

The following will be added to Section 5.1.2.2 (3): "The V&V Team shall ensure all items in the HFE Issues Tracking System have been completed at the appropriate phase of the design process".

The following will be added to Section 5.1.2.2 (4). "The QA Organization shall conduct period audits of the design and V&V processes, which include disposition of items in the HFE Issues Tracking System".

**Follow-up RAI:**

MHI's response states who is responsible for issues tracking but does not provide detail on the tracking system including how it will help provide reasonable assurance that HFE issues that need to be addressed before the design process is completed are not overlooked.

Please provide in greater detail how the tracking system will help provide reasonable assurance that HFE issues that need to be addressed before the design process is completed are not overlooked.

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**ANSWER:**

A detailed description of the HFE issues tracking system, and how it is used throughout the HFE program, is provided in the HFE Implementation Procedure, which will be provided in the HSI Design report to be submitted by June 30, 2009. This procedure demonstrates that the HFE issues that need to be addressed before the design process is completed will not be overlooked.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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Follow-up RAI to RAI NO. : 18.0-20

Clarification of HFE issue threshold of significance.

MHI states that the HFE issues are entered into the HFE Issues Tracking Systems as well as actions taken to address the issues, resolutions of issues, and the design team's acceptance of the resolutions. MHI states that issues are entered into the HFE Issues Tracking System if they meet or exceed "the threshold of significance established by the design team." It follows that if a significance threshold is too high an issue that needs to be addressed at a later date will not be entered into the tracking system and there may be no assurance that the issue will be attended to. Please define how the threshold of significance value for deciding to enter HFE issues into the HFE Issues Tracking System is determined.

#### MHI Response:

The document will be revised as follows: There is no significance threshold for issue entry into the tracking system. Each issue or concern entered into the system is evaluated for its significance to human performance. The basis for the disposition of all entries is included in the database.

#### Follow-up RAI:

The response given by MHI does not clarify the criteria for which issue (or concern) is entered into the issues tracking system or not. Please clarify, in greater detail, the methodology MHI will use to evaluate the significant human performance issues or concerns.

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#### ANSWER:

The Integrated HRA report in "US-APWR HSI Design Technical Report" which will be submitted in June, 2009 describes the HED data base and tracking system for HFE design elements. This report explains how items are entered into the database and how the entries are resolved. In summary, there is no screening of issues entered into the database, and all issues entered are evaluated in the same manner by the HFE Expert Panel. The HFE Expert panel adds the significance categorization as an aid in

evaluating potential options for issue resolution. All issues in the database will be closed during the phased HSI program.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-24****Clarification of HFE facilities, equipment, tools, and techniques.**

MHI states that "static and dynamic models" will be developed to evaluate the HSI design and a part-task simulator that is used for HFE activities. There is no definition of what static models and dynamic models are and little detail on how they will be used in the HFE program. Please explain static models and dynamic models and how they will be used in the HFE program. Little detail is provided on the tools and techniques used to develop the hardware and software interfaces for US-APWR, such as graphic user interfaces (GUIs), panel layouts, procedure design, etc. Please provide further explanation about the tools and techniques used to develop the hardware and software interfaces for US-APWR, such as GUIs, panel layouts, procedure design, etc. There is discussion of a part-task simulator, a "complete control room full scope simulator," and a simulator facility, but little detail is provided about these and how they will be used in the HFE program. Please explain the use of the different simulator types. Two images of a facility used for HFE verification and validation in Japan are shown in Appendix B, but no explanation is given for how the facilities depicted in these images related to the design of US-APWR. Please explain how the facilities relate to the US-APWR design.

**MHI Response:**

The document will be revised as follows: "The HSI design implementation activities include the development of static graphic displays, and dynamic graphic displays driven by high fidelity plant model simulators... Static graphic displays are used for the following verification activities: (1) Conformance to NUREG0700 design criteria (2) Confirmation of HSI inventory with operating procedures (3) Confirmation of usability with task analysis. The dynamic graphic displays driven by high fidelity plant model simulators are used to... Verification activities, using static graphic displays are conducted prior to verification and validation activities, using dynamic displays driven by high fidelity plant models."

The process for creating computer based procedures is described in Section 4.8. Another similar section will be added to the Topical Report that describes the process for creating static displays (e.g., display icon library, conformance to HFE style guide)

and then converting them to dynamic displays (e.g., linking to live points in the I/O database).

As described in Section 5.1.5, part-task simulators are used at the early design stage, for verification of the graphic displays for each plant system. The following will be added: "A Full scope simulator is used for integrated validation testing."

A description of the use of full scope simulators during each phase of HSI development will be added to the Topical Report, as described in the response to RAI-4.

These pictures show the Japanese HSI System. As explained in the Abstract of this Topical Report, the Japanese HSI System is the basis (reference design) for the US HSI System, which will be applied initially to the US-APWR.

**Follow-up RAI:**

The staff reviewed MUAP-07007-P Revision 2 (September 2008) and did not find the text quoted in the response. Please clarify where this text can be found in the topical report. Additionally, please clarify the meaning of the last sentence of the first paragraph.

Also, please give detailed information to satisfy the criteria for specifying HFE facilities, equipment, tools, and techniques to be used for the HFE program.

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**ANSWER:**

The changes identified in the previous RAI response will be added in the next version (Revision 3) of the Topical report. However, the last sentence of the first paragraph will be modified as follows:

Verification activities, using static graphic displays are conducted prior to validation activities, using dynamic displays driven by high fidelity plant models.

The Implementation Procedure for each HFE program element describes the HFE facilities, equipment, tools, and techniques used to implement that program element.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-25**

**Description of assurance that plant modifications meet current regulations.**

MHI seeks NRC approval of the HSI system design for "replacement of current HSI systems in operating plants" but there is no discussion in the topical report of how MHI will address plant modifications. The HFE plan should provide assurance that plant modifications meet current regulations, except where specific exemptions are requested under 10 CFR 50.12. Please describe how the HFE plan will provide assurance that plant modifications meet current regulations.

**MHI Response:**

As stated in the Abstract: "For applications in the US, this report demonstrates conformance of the HSI System design and design process with all applicable US Codes and Standards." Conformance to current regulations is assured through Staff approval of this Topical Report and the LAR that will reference this topical report and provide supplemental plant specific documentation. MHI is not planning any exemption requests.

**Follow-up RAI:**

MHI's response asserts that the Topical Report provides information demonstrating that the HSI design and design process meets relevant US Codes and Standards. Moreover, the response asserts that the staff assures compliance to current regulations by approving the Topical Report and the LAR used for plant modifications. The Topical Report does not demonstrate conformance of the HSI System design and design process with all applicable US Codes and Standards. The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in satisfying the criteria for providing assurance in the HFE plan that a plant modification meets current regulations.

Please provide detailed information describing how the HFE plan will provide assurance that plant modifications meet current regulations.

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**ANSWER:**

A licensee that references this Topical Report will implement the plant specific HSI Inventory using the Basic HSI System features described in this report, including the implementation methods for compliance to all regulatory guidance for safety related HSI and HSI for degraded conditions. The integrated plant specific HSI System will be developed following the HFE program plan key elements also described in this report, including the key elements for analysis, HSI design, training and V&V. The Basic HSI System and key HFE program plan elements referenced in this topical report, will be supplemented by a complete plant specific HFE program plan, and a complete description of plant specific HSI design features, such as the "minimum inventory", which will be provided in the licensee's LAR. Chapter 18 of the US-APWR DCD exemplifies the complete HFE program plan that would be submitted as part of the licensee's LAR.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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Follow-up RAI to RAI NO. : 18.0-27

#### Clarification of OER implementation plan.

The Operating Experience Review (OER) is described in Section 5.2. According to NUREG-0711, Rev. 2, the OER “should provide administrative procedures for evaluating operating, design and construction experience and for ensuring that applicable important industry experiences will be provided in a timely manner to those designing and construction the plant.”

MHI states in the topical report “MHI has examined and addressed the issues and causes of the events in the past commissioning and/or the present operating plants, both domestic and overseas, and improved the in-service plant facilities and the construction plant designs if necessary in order to avoid the issue again.” (p. 99)

This is not sufficiently detailed to evaluate. The NUREG-0711, Rev. 2 criteria for OER include a review of predecessor or related plants and systems, review of recognized industry issues and related HFE technology, interviews with plant personnel, and identification of risk-important human actions. The topical report does not describe the scope of the OER, or the review process, or address any of the aforementioned criteria. Please provide detail on the plan to implement the OER, including methods and how other NUREG-0711, Rev. 2 OER criteria will be addressed.

#### MHI Response:

The following will be added to Section 5.2: “Each application of MHI’s HSI System will build upon previous applications. For example, the first US-APWR will build upon the application of the HSI System to Japanese plants. The first application of the HSI System to an operating plant, will build upon the application to the US-APWR. Therefore the scope of OER and the specific plan for that OER is described in plant specific licensing documentation.”

#### Follow-up RAI:

The response simply states that the OER implementation plan will build upon previous applications of the HSI System to operating plants and, because of this, will be described in other licensing documentation. A review of the operating experience of a

similar HSI is necessary of any OER, and the response does not specify detail for a plan of how an OER will for the US-APWR HSI design be implemented. An OER is a necessary precursor to a design. Please provide a plan for how the OER will be implemented for staff review.

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**ANSWER:**

The key elements of the OER Program Plan, which are described in Section 5.2 of the Topical Report, is supplemented by a complete OER Program Plan in plant specific licensing documentation. For example, for the US-APWR, the complete OER Program Plan is provided in Section 18.2 of the DCD. The US-APWR OER Program Plan resulted in the OER procedure and report documented in Part 2 of "US-APWR Human System Interface Verification and Validation (Phase 1a) Technical report" (MUAP-08014), which was submitted for Staff review in December 2008.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-28**

**Detail and clarification of the OER.**

MHI states that they have "examined and addressed the issues and causes of events in the past commissioning and/or present operating plants," and improved designs if necessary to avoid the issue again. This implies that an OER has already been performed, but no results are presented. There is no discussion of whether or not the past commissioning and the present operating plants that were examined are considered predecessor plants – predecessor plants are those that have designs upon which the US-APWR design will be based. It is unclear if the issues identified in this examination have been incorporated into the issues tracking system of the US-APWR HFE program. Table 5.2-1, almost illegible, and it does not appear to address any human factors issues. Please provide detail on what predecessor designs or highly similar plants or plant systems have already been examined for the OER, what methodologies were used to review them, and how the issues identified from this review were/are/will be documented and tracked for the US-APWR HFE program. Also, MHI should clarify the status of the OER and indicate when the results will be available for review.

**MHI Response:**

As described in Section 4.0 "This topical report describes the HFE elements that were encompassed in the development program in Japan. Table 4.0-1 compares the NUREG0711 HFE program elements to the elements in the HFE program implemented for Japanese PWRs." Section 5.2 describes the OER process that has been completed for the Japanese HSI System. This same OER process is applicable to future applications. As stated above, each application builds upon the OER from each previous application of the HSI System. Therefore, the scope of OER and the specific plan for that OER is described in plant specific licensing documentation.

The Japanese HSI System design reflects the resolution of all OER issues that were identified. Since the Japanese HSI System is considered the predecessor design for the US-APWR, these issues do not exist in the US-APWR issues tracking database. The US-APWR issues tracking database will include only new issues, which are identified during the US-APWR OER activity, as described in the US-APWR DCD. Again, the US-APWR OER builds upon the work previously conducted for the

predecessor reference design. The US-APWR OER will include a review of the corrective actions database for CPNPP 1&2, to identify issues that may be generically applicable to all US applications. The US-APWR OER will be completed 12/2008. The resolution of any HEDs identified by that OER will be reflected in the final Basic HSI System which will be documented in a revision to this Topical Report, by 06/2009. The basis for all changes to the Basic HSI System currently documented in this Topical Report, will be explained.

**Follow-up RAI:**

The response does not provide details describing what kind of findings were obtained in the Japanese OER, or how they were resolved. The Japanese HFE process, including the OER, has not been certified as a process that can be referenced in a US application.

The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in addressing the information requested by the staff for RAI 18.0-28. Please provide the detailed information describing what kind of findings were obtained in the Japanese OER and how they were resolved.

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**ANSWER:**

The OER report in Part 2 of "US-APWR Human System Interface Verification and Validation (Phase 1a) Technical report" (MUAP-08014) identifies issues that were obtained in the Japanese OER that impacted the Japanese Standard HSI System, and are therefore pertinent to the US Basic HSI System.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-30**

**Clarification of functional analysis and allocation methodology.**

Functional Requirements and Functional Allocation is described in Section 5.3 of the topical report. NUREG-0711, Rev. 2 states that "Functional requirements analysis and function allocation should be performed using a structured, documented methodology reflecting HFE principles." The topical report illustrates the hierarchical structure of plant functions and describes some rules for the application of automation (pp. 100 – 103), but no detail is provided on the methodology employed to perform the functional analysis and allocation and there is no explanation of the basis for developing the rules. Please provide detail on the methodology that was employed to perform the functional analysis and allocation and the basis for developing rules used for function allocation.

**MHI Response:**

As stated in Section 5.3 "...the functions and allocations are based primarily on historical practices ...Therefore the focus of this HFE effort is to identify any changes from historical practices (i.e., a detailed evaluation of unchanged practices is not ... conducted)." Therefore, the following will be added to Section 5.3: "The report for this element identifies all function allocation changes from the reference plant, including the reason for those changes and technical justification regarding human performance in accordance with the methodology and criteria described in Sections 5.3.1 and 5.3.2." MHI plans to complete the FRA/FA of the US-APWR by the 6/2009 as shown in Attachment-1.

For an operating plant, the FA will start with what exists at the plant today. This HFE program element will only analyze changes, which may be none. New HSI does not always result in function allocation changes.

**Follow-up RAI:**

The response indicates that FRA/FA has not been completed for the US plant, and simply stating that FRA/FA is based on "historical practices" does not allow evaluation of how the FRA/FA was completed for the Japanese reference plant. The Japanese HFE process, including the FRA/FA, has not been certified as a process that can be

referenced in a US application. The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in addressing the information requested by the staff for RAI 18.0-30.

Will the completed FRA/FA technical information include both the Japanese (reference plant) FRA/FA, and the differences between that plants FRA/FA and the US-APWR's FRA/FA?

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**ANSWER:**

The completed FRA/FA technical information will be included in "US-APWR Human System Interface Design Technical report". This report describes the function allocation for all functions of safety significance. The emphasis of the report is the justification of changes from historical practices. To date, the Standard Japanese HSI has been applied only to conventional PWRs that have the same historical function allocations as PWRs in the US. Therefore, since the FRA/FA basis is the same as conventional US PWRs, there is no reason for the Staff to evaluate the FRA/FA for the Japanese reference plant. Prior FRA/FA analysis that is pertinent to the US-APWR is included in the "US-APWR HSI Design Technical report".

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-31**

**Clarify functional analysis and allocation content.**

NUREG-0711, Rev. 2 states that plant functions and systems be described in detail, including the technical basis for all function allocations (see NUREG 0711 Functional Requirements and Functional Allocation criteria 3 – 6). Please detail the implementation plan for the types of content that will be addressed for functional analysis and allocation.

**MHI Response:**

See response 18.0-30.

**Follow-up RAI:**

RAI response 18.0-30 is unacceptable and is not a satisfactory response for RAI 18.0-31. Please detail the implementation plan for the types of content that will be addressed for functional analysis and allocation.

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**ANSWER:**

The FRA/FA Implementation Plan provided in Section 18.3 of the US-APWR DCD describes the types of content that will be addressed for functional analysis and allocation. This includes the purpose, conditions, parameters, criteria and rationale for the allocation of actions for all safety functions. The FRA/FA in "US-APWR Human System Interface Design Technical report" which will be submitted in June will identify the FRA/FA implementation procedure and results.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-32**

**Clarify plan to analyze situational awareness.**

NUREG-0711, Rev. 2 states that the allocation analysis consider the responsibility of personnel to monitor automatic functions and to assume control in the even of an automatic system failure (p. 22, criterion 8). The general rules for automation articulated on pages 100 – 101 of the topical report emphasize task frequency, repetitiveness, workload and accuracy. There is no discussion of the need for operators to maintain situational awareness of automated system performance. Please describe the plan for analysis of this issue.

**MHI Response:**

MHI uses the function analysis element to define the allocation between manual operations and automation. For critical automated functions, situation awareness is assured through the identification of the Minimum Inventory of SDCV indications and alarms, as described in section 4.12.d. The SDCV Minimum Inventory is identified through the Task Analysis, as stated in Section 5.4.2 "...where critical functions are automated, the analyses should consider all human tasks including monitoring of the automated system and execution of backup actions if the system fails".

**Follow-up RAI:**

While SDCV indications and alarms can potentially be one way to support situation awareness, information should be provided that details a plan for analyzing situation awareness, a property of the human operators, not a property of the technology in the control room. For instance how, with MHI, do situational awareness analyses provide information about how operators could dynamically infer the proper functioning of automated systems that may not have exceeded alarm threshold limits? Please provide detailed clarifying information describing the plan for operator situational awareness of automated system performance.

---

**ANSWER:**

The main HFE elements that address the ability of operators to maintain situation awareness of the status of automated systems and whether they are functioning

properly are: HSI design, task analysis, and person-in-the-loop testing, which is included in the validation activities of all three HFE program phases.

The task analyses to be performed during Phase 2 in conjunction with operating procedure development will specifically address the supervisory role of MCR operators with respect to critical safety and power production functions that are automated. This includes monitoring of the automated systems and execution of backup actions if the system fails. The TA will include identification of information requirements to enable operators to determine whether automated systems are functioning correctly and achieving desired plant safety and production goals, and the information and controls required for the operators to perform backup actions if the system fails.

The HSI design includes a number of features intended to support the ability of operators to maintain situation awareness of the status of automated systems, their availability status, and whether they have successfully executed when needed. Examples include the SDCV BISI and OK status monitors that are provided on the LDP. SDCV trend arrows, also included on the LDP, allow operators to quickly detect the incorrect functioning of automated systems that may not have exceeded alarm threshold limits, and to easily monitor the proper functioning of automated systems that are working to return systems to normal threshold limits.

The MHI person-in-the-loop testing program explicitly addresses the ability of operators to maintain situation awareness of the status of automated systems. The role of operators as supervisors of automated systems was explicitly addressed in the Phase 1b V&V program. Several of the validation test scenarios included instances where automatic safety systems failed or partially failed to come on as required. The evaluation examined the ability of operators to detect the failures and to manually take-over the function.

The MHI person-in-the-loop testing program utilizes multiple different measures of situation awareness, including objective and operator subjective measures of situation awareness.

Objective measures of situation awareness are obtained by inserting specific events into simulator scenarios (e.g., equipment malfunctions, systems placed in manual that should be in automatic) and recording whether operators are able to detect them. This provides an objective indication of operator situation awareness.

Operator subjective measures of situation awareness are obtained via Likert rating scale questions that are included in questionnaires that operators are asked to fill out, following each simulator scenario. Situation awareness was explicitly measured in the Phase 1a and b person-in-the-loop evaluations using these two techniques.

Situation awareness is a complex, multi-dimensional construct. MHI intends to establish that the US-APWR HSI effectively supports operator situation awareness by utilizing multiple different measures of situation awareness that produce converging results.

#### **Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-37**

**Clarify GOMS timing analysis.**

The Detailed level Task Analysis Method is described, based on the goals, operators, methods, and selection rules (GOMS) model (p. 107 – 108). This model provides useful distinctions between perception, cognition and motion, but the staff is unclear as to the value of the timing analysis. If applied to the range of tasks required for full analysis of the plant design, it seems that this could easily overwhelm the human factors team, and it is not clear how the analysis is related to the NUREG-0711, Rev. 2 criteria. Please clarify the value provided by the GOMS timing analysis, how the resulting data will be used, and how it fulfills the NUREG-0711, Rev. 2 criteria for Task Analysis.

**MHI Response:**

The following descriptions to Section 5.4.3.2 will be add;

GOMS is used only for tasks that meet all of the following criteria:

1. Significant changes from the reference design or tasks where there is no operating history in the reference design.
2. Where the tasks are identified as risk significant through the HRA element.
3. Where the task is time critical.

GOMS is a technique similar to operational sequence diagrams. The GOMS analysis is based on preliminary operating procedures.

MHI plans to execute all task analysis for the US-APWR based on differences from the Japanese standard PWR. The GOMS analysis assumes the number of crew members to be one licensed-SRO and one licensed-RO and based on the minimum staffing for the US-APWR. Cognitive workload can be estimated to determine the HSI inventory of alarms, displays, and controls necessary to perform crew tasks.

**Follow-up RAI:**

MHI's response does not address the information requested by the staff. Please give detailed information clarifying the value provided by the GOMS timing analysis, and how it fulfills the NUREG-0711, Rev. 2 criteria for Task Analysis.

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**ANSWER:**

The US-APWR Task analysis in "US-APWR Human System Interface Design Technical report" which will be submitted in June, 2009 provides more details on the US-APWR TA methodology, and the purpose for conducting the GOMS timing analysis.

The GOMS analysis is primarily used as a preliminary method for estimating the amount of time that will be required for operators to complete risk important human actions (HA). These time estimates are compared to the time windows within which the HA need to be completed as defined by HRA and safety analyses. The objective of the GOMS analysis is to provide preliminary confirmation that the HA can be completed within the time limits identified in the PRA and safety analyses.

As explained in the TA section of the report to be provided in June, the MHI TA Implementation Procedure includes a second table-top method that provides an independent check that the HA can be accomplished within the time window specified by the PRA and safety analyses. This table top analysis is performed by two operations experts (both SRO Instructors with plant experience) who are familiar with U.S. NPP operations and the MHI U.S. Basic HSI System.

As explained in the TA section of the report to be provided in June, the MHI TA Implementation Procedure includes three analysis methods - OSD, GOMS and the table top evaluation - to fulfill the NUREG-0711, Rev. 2 criteria for Task Analysis.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-38**

**Clarify intention for operating staff analysis and how results will be used by Combined License applicants.**

MHI states in the Staffing and Qualifications section that the "Final Staffing and Qualification requirements depend on the operating utility's applications; therefore it is a Combined License applicant responsibility." While it is appropriate that the COL applicant be responsible for the final staffing and qualifications analysis and results, MHI does define minimum and maximum operating staff in this topical report. The discussion of numbers of operating staff in Section 5.5.2 bases the minimum and maximum numbers on NRC regulations – there is no analysis described to determine the numbers of operating staff needed to operate a US-APWR plant safely in a full range of plant conditions, which could conceivably be higher than that required by NRC regulations. Will MHI conduct a full staffing analysis for operating staff? Does MHI expect that the operating staff analysis carried out by COL applicants must comply with the results for minimum and maximum operating staff presented in this report?

**MHI Response:**

The following will be added to Section 5.5: "The plant specific report for the Staffing and Qualifications program element will define the staffing and qualifications for personnel that perform operations or maintenance tasks directly related to plant safety. The report will define the basis for the staffing numbers and qualification requirements, with justification for changes from the reference plant. Staffing will be confirmed through Task Analysis and V&V program elements."

MHI expects applicants to comply with the minimum and maximum operating staffing defined in this report, or to conduct additional Task Analysis and V&V to justify the changes.

**Follow-up RAI:**

MHI's response refers to providing justification for changes to staffing numbers and qualification requirements from the reference plant. What is the reference plant?

MHI's response does not provide information that addresses the staff's request. Was an operating staff analysis carried out to determine the minimum and maximum staff defined in the Topical Report? If so, please describe the operating staff analysis methodology that was used.

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**ANSWER:**

The minimum staffing defined in the Topical Report is based on the V&V experience in Japan, which is described in Appendix B. The maximum staffing is based on current operating practices in the US for conventional PWRs. The Basic HSI System was validated in Phase 1a with scenarios that included both minimum and maximum staffing. The test results are report in the Phase 1a report, which was submitted to the Staff December 2008. For the US-APWR the Staffing Analysis program element will be conducted during Phase 2b.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-40**

**Clarify the HRA plan.**

MHI provides no discussion of how risk-important human actions will be identified from the probabilistic risk analysis (PRA)/HRA and how these risk-important human actions will be used as input to the HFE design. There is a process flow figure (Figure 5.6-1) that shows PRA and HRA as individual items in the process flow and both PRA and HRA appear to have inputs into the gross-level task analysis, but there is no explanation of this figure, so any conclusions about how PRA and HRA fits into the overall HFE process are uncertain. Please provide detail on how risk-important human actions will be identified in a way that will provide reasonable assurance that important actions are not overlooked and how results of the PRA/HRA will be used as input into the HFE design process.

**MHI Response:**

Risk important human actions are identified in the PRA. The methods used by the PRA analysis to identify these actions is not within the scope of this HFE element, and therefore not explained in this Topical Report. MHI would expect the NRC to conduct a thorough review of each plant specific PRA to ensure risk significant human actions are appropriately identified.

The scope of this HFE element is to ensure that for those human actions that are identified in the PRA as risk significant, the appropriate probability of human error is defined. As stated in Section 5.6.4 "HRA sheets are prepared for tasks corresponding to risk important HAs." In addition, this element ensures that these risk significant human actions are considered in each HFE program element to ensure the HSI design has minimized the probability of human error for these risk significant human actions. Risk-important human error analysis has been done in the US-APWR PRA, and will be evaluated internally with the modifications of the design. The HRA for the US-APWR will be completed by 6/2009.

**Follow-up RAI:**

The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in clarifying the HRA plan.

The response indicates that the methods for identifying risk-important human actions from the PRA are not within the scope of the HRA element. Per NUREG-071, Rev. 2 Section 7.4(1), risk-important human actions should be identified from the PRA/HRA and used as input to the HFE design effort. The methodology used by the PRA/HRA analysis to identify these risk-important HAs is within the scope of this HFE element.

Please provide sufficient detail on how results of the PRA/HRA will be used as input into the HFE design process.

**ANSWER:**

Risk Important Human Actions (HAs) for the US-APWR are derived from the level 1 and 2 PRA, through the methods described in "MUAP-07030 US-APWR Probabilistic Risk Assessment Chapter 9" Technical Report.

The following will be added to the Topical Report:

5.6.5 HRA Integration

Risk-important HAs are integrated into the HFE program as follows:

- Risk-important HAs and their associated tasks and scenarios are specifically addressed during function allocation analyses, task analyses, HSI design, procedure development, and training development. Proper consideration of HAs helps verify that these tasks are well supported by the HSI design and can be executed within acceptable human performance capabilities (e.g. within time and workload requirements).
- The HFE design team characterizes risk-important human-system interactions by identifying the performance shaping factors (PSF). The team then applies HFE guidelines to the HSI to optimize the PSF, thereby enhancing the overall human success probability.
- HRA assumptions such as decision-making and diagnosis strategies for dominant sequences are validated by walkthrough analyses with personnel with operational experience using a plant-specific control room mockup or simulator. Reviews are conducted before the final quantification stage of the PRA as part of the V&V process.
- The V&V Team ensures V&V activities are designed to specifically address human performance for risk-significant HAs. The verification analysis is most rigorous for HSI that supports tasks shown by the HRA to be risk significant. Verification includes operating procedures and training material. In addition, the validation scenarios encompass all human actions shown by the HRA to be risk significant. Validation encompasses the complete HSI design, including operating procedures, and is conducted with operators that have been trained in accordance with the HFE training program. Human performance for risk significant HAs is specifically monitored during validation scenarios.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-42**

**Clarify process for addressing risk-important HAs.**

There is some discussion of how risk-important HAs and associated tasks and scenarios as identified by the PRA/HRA will be addressed during function allocation analyses, task analyses, HSI design, procedure development, and training. MHI does state that a human factors engineer and systems safety engineer will be members of the procedure development team and will provide PRA/HRA results and that the procedure content will incorporate "important human actions." MHI also states that HAs that have been identified as risk-significant by the PRA will be considered in the task analysis, however there is no discussion of how the identified HAs will be used as part of the task analysis. In addition, MHI states that the results of the PRA and HRA will be used as inputs to the HSI design process but no detail is provided on how the PRA/HRA results will be used for HSI design. Please provide detail on how risk-important HAs and associated tasks and scenarios as identified by the PRA/HRA will be addressed during function allocation analyses, task analyses, HSI design, procedure development, and training.

**MHI Response:**

During functional allocation, automation is evaluated for risk significant HAs. For tasks that remain allocated to human actions, the Task analysis assesses the workload for these HAs. In order to reduce the workload, staffing changes, HSI design improvement, operation procedure improvement and/or training improvement are assessed in subsequent program elements. The result of HSI design and staffing changes are confirmed during HSI V&V activities. V&V activities also confirm the assumptions made during preparation of the HRA sheets. Risk significant HAs are specifically tracked and discussed in each program element report. This is ensured through the HFE implementation procedure and the QA review process.

**Follow-up RAI:**

MHI's response does not provide sufficient detail in describing how risk-important HAs and associated tasks and scenarios as identified by the PRA/HRA will be addressed during other HFE program elements. For instance, how will automation be evaluated

for risk-important HAs in the function allocation analysis? Also, for instance, how does the task analysis assess workload for risk-important HAs?

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**ANSWER:**

The HSI Topical Report, MUAP-07007, is only intended to identify the key elements of the HRA program plan. Additional program details are provided in plant licensing documentation. The HFE Overall Implementation Procedure in the "US-APWR Human System Interface Design Technical Report" which will be submitted in June, 2009 describes the program management and integration of the HFE program with the HSI design for the US-APWR. Important human factors issues that may affect performance are discussed in the element specific sections of the "US-APWR Human System Interface Design Technical Report". This includes FRA, FA, TA, HRA, the HSI Test and Evaluation and final V&V program.

The Task analysis report and the function analysis report in "US-APWR HSI Design Technical Report" which will be submitted in June, 2009 describes how the identified risk important HAs are used as part of the task analysis and how issues such as work load and effects of automation are included. In addition, the issues of cognitive and physical workload, effects of automation on human performance and the evaluation of how the HSI supports risk important HAs are included in the testing program and therefore are discussed in the HSI Test and Evaluation Report. This testing program makes up an important part of the HSI integrated design process and has been ongoing in the US for the last year. The first set of test results were submitted to the NRC in December 2008 ,report MUAP-08014-P R0. The second set of test results are presented in the HSI Test and Evaluation (V&V) Test report in the "US-APWR Human System Interface Design Technical Report" which will be submitted in June.

The integrated HRA report in "US-APWR Human System Interface Design Technical Report" which will be submitted in June, 2009 describes how the PRA/HRA and specifically the risk important HA results are used as HSI design input.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-43**

**Clarify the process for addressing errors from risk-important HAs.**

There is little discussion of how HSI design, procedure development, and training design will be used to address risk-important HAs, as identified by PRA/HRA results, to minimize the likelihood of operator error and provide for error detection and recovery capability. MHI does state that the HRA will be used as an input to the training development program to reduce the likelihood and consequences of errors from risk-important HAs, but there are no specifics on how the HRA will be used for this. Please provide detail on how the HFE process for HSI design, procedure development, and training design will be used to address risk-important HAs, as identified by PRA/HRA results, to minimize the likelihood of operator error and provide for error detection and recovery capability.

**MHI Response:**

Please see response on RAI 18.0-42.

**Follow-up RAI:**

MHI's response simply refers to the response to RAI 18-42. The response to RAI 18.0-42 does not address the information requested by the staff for RAI 18.0-43. Please provide detailed information describing **how** the HFE process for HSI design, procedure development, and training design will be used to address risk-important HAs, as identified by PRA/HRA results, to minimize the likelihood of operator error and provide for error detection and recovery capability.

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**ANSWER:**

Section 5.6.5 HRA Integration, that will be added to the Topical Report, describes how risk-important HAs are integrated into the HSI design, procedure development and training (see response to RAI 18-40). As stated, the HFE V&V team ensures risk-important HAs are adequately addressed through validation activities that specifically monitor human performance.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-44**

**Clarify HRA assumption validation process.**

There is no discussion of how identified HRA assumptions will be validated. HRA assumptions may be validated by walkthrough analyses with personnel with operational experience using a control room mockup or simulator. Please provide detail on how identified HRA assumptions will be validated.

**MHI Response:**

HRA assumptions will be validated in the V&V stage. In the early design stage, they are verified using a static display navigation system with walkthrough and display selections analyses. In the final design stage, they are validated through operability testing using a US-APWR simulator with licensed plant operations personnel.

**Follow-up RAI:**

The staff does not understand MHI's response. MHI states that HRA assumptions will be validated in the V&V stage and MHI states the HRA assumptions will be validated in the Design stage. Are the HRA assumptions validated in both the Design and V&V stages?

The response does not provide sufficient detail. The methodology for HRA assumption validation in the V&V stage is not described. The methodology for HRA assumption validation in the design stage does not significantly describe the methodology used.

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**ANSWER:**

The HRA assumptions for the US-APWR are validated throughout the design process, as follows;

1. review and assessment by the HFE Expert Panel, composed of members of the HFE V&V and HFE Design team, and independent from the HRA team.

2. paper and pencil walk throughs conducted by independent analysts with operating, training and procedure development experience.
3. HSI tests and evaluations using, full scale dynamic simulation with real time operator in the loop scenario tests. Some tests were conducted during Phase 1 V&V. Additional tests will be conducted during Phase 2 V&V.

All findings from each of the four steps will be communicated back to the HRA/PRA analysts through meetings and written communications. The Phase 2b final V&V will serve, in part, as a confirmation of the final set of HRA assumptions that have evolved as an outcome of the iterative HFE design process.

The integrated HRA report in "US-APWR HSI Design Technical Report" which will be submitted in June, 2009 will describe identification of risk important human actions from the PRA/HRA results and how these human actions are considered to HSI design input and procedure development.

#### **Impact on DCD**

There is no impact on DCD.

#### **Impact on COLA**

There is no impact on COLA.

#### **Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-45**

**Clarify procedures will address NUREG-0800, Section 13.5 requirements.**

MHI does not state that procedures for US-APWR will address applicable requirements of NUREG-0800, "Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants," Section 13.5. What is MHI's plan for making sure that procedures will address applicable requirements of NUREG-0800, Section 13.5?

**MHI Response:**

This element ensures appropriate HFE principals and HFE Design Team engagement in the development of operating procedures. Conformances to the specific requirements of NUREG-0800 are assured through HFE Design Team participation in the development of the procedure writers guide, and verification of the operating procedures by the HFE V&V Team.

**Follow-up RAI:**

The response does not significantly describe the methodology used to ensure that procedures will address applicable requirements of NUREG-0800, Section 13.5. Please clarify in greater detail what MHI's plan is for making sure that procedures will address applicable requirements of NUREG-0800, Section 13.5.

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**ANSWER:**

The specific methodology for developing procedures which comply with the Standard Review Plan NUREG-0800 13.5 are addressed in DCD Section 13.5. COL action items identified in the DCD are addressed in FSAR Chapter 13 for the US-APWR. The COL Applicant is to develop procedures specified in FSAR Chapter 13. For HSI modernization in operating plants, similar commitments will be identified in the plant specific licensing document. The description of the HSI/HFE Topical Report shows that the development of the operating procedure has interface with the HSI design and HFE process.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-46**

**Clarify basis for procedure development.**

Though MHI states the task analysis results will provide the basis and input for procedure development (Sections 5.4.1, 5.4.2) and that members of the procedures development team will be responsible for providing tasks analysis results and results from the PRA/HRA on risk-important human actions (Section 5.8.2), there is no detail on what the basis for procedure development will include. Please provide detail on what will provide the basis for procedure development.

**MHI Response:**

Procedures are based on the procedures from the reference plant. Changes to those procedures are technically justified based on plant design documentation. Procedures are an integral part of the HSI system, therefore they are included in the V&V process.

**Follow-up RAI:**

The response indicates that procedures are based on procedures from the reference plant, but there is no definition of what the reference plant is. Procedures from a plant referenced by US-APWR licensing documentation shall be approved by the NRC. The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in clarifying the basis for procedure development. Please provide detailed information describing what will provide the basis for procedure development.

---

**ANSWER:**

The following will be added to Section 5.8.2:

The basis for procedure development comes from the Task Analysis, as shown in Figure 5.4-1, and from operating procedure guidelines developed by plant system designers. Procedures from reference US operating plants are also evaluated to ensure differences are justified based on plant design

differences. The US operating plant references are identified in plant licensing documentation. The procedure basis also includes HEDs resulting from any HFE program element, including V&V activities, whose resolution requires procedure emphasis. Procedure emphasis may also be warranted for risk-significant HA's identified in the HRA.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-50**

**Clarify entry conditions for EOPs.**

In the discussion of emergency operating procedures (EOPs) in Section 5.8.1.b, MHI list two types of procedures: event-based and symptom-based. There is no explanation given for event-based versus symptom-based procedures other than the types of events and safety functions they address. Typically, event-based procedures use entry conditions that are based on the origin of an event, while symptom-based procedures use entry conditions that are based on indirect, observable effects of an event. Please detail how entry conditions for EOPs will be determined and, if there are different kinds of entry conditions for event-based procedures versus symptom-based procedures, please explain what the differences are.

**MHI Response:**

This document does not explain “event based” and “symptom based” since these are well understood terms in the nuclear industry. MHI does not intend to change these philosophies for the US-APWR or for operating plants. Reference plant procedures will be modified only to accommodate the new HSI, not to change the approach to event mitigation.

**Follow-up RAI:**

The information provided in the response does not address the RAI. Entry conditions for EOPs should be symptom-based. The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in clarifying the entry conditions for EOPs.

Have Generic Technical Guidelines (GTGs) been developed for the reference plant? Information should be described here... are these available for review? What are the differences between reference plant and US-APWR?

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**ANSWER:**

There is not much difference for the EOP entry conditions between reference plant (US and Japanese Westinghouse-type PWR) and the entry conditions for plants that adopt the Basic HSI System. Section 5.8.1b will be modified as follows:

The approach adopted for the Basic HSI System to provide accident response operation consists of both event-based and symptom-based emergency operating procedures (EOP). As in US PWRs, operators enter the highest level emergency procedure (typically referred to as E-0) based on a reactor trip or ESF actuation. Steps within the highest level EOP lead operators to event specific EOPs, or symptom-based EOPs which direct actions to monitor and maintain critical safety functions. The principal characteristics of this approach are the following:

The US-APWR Emergency Response Guidelines (ERGs), which establish the basis of the US-APWR Emergency Operating Procedures (EOP), are being developed by MHI in two phases. Phase 1 will develop a draft ERG that reflects the US-APWR design, and will include US industry input. The Phase 1 draft ERG will be completed by the end of 2009. During Phase 2 (January 2010 to December 2012) MHI will add detailed design-specific bases and add equipment details such as MHI component IDs. During Phase 2 MHI will also develop a draft EOP for use by US-APWR COL applicants.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-51**

**Clarify procedure V&V process.**

Little detail is given on how procedures will be verified and validated. MHI states that the procedures will be validated in an integrated system validation, but there is no description of an integrated system validation as described in NUREG-0711, Rev. 2 Section 11, which should involve the use of a simulator or other representation of the integrated system. Please explain how the process to verify and validate procedures will address how procedures will be verified that they are correct and can be carried out, how the final validation of procedures will be realized using an integrated system simulation, and how modified procedures will be verified with respect to content, format, integration, and effect on personnel tasks significant to plant safety.

**MHI Response:**

Section 5.8.2 states "The procedures are ... validated and finalized in the integrated system validation described in section 5.10." Section 5.10.2.1.b describes the personnel tasks that are included in the Integrated validation, including "... tasks that are well defined by normal, abnormal, emergency, alarm response, and test procedures". Section 5.10.2.2.4.b states "The validation test facility ...is a full scale HSI mockup with a full-scope simulator." Section 5.10.2.2.2 will be clarified as follows: "5.10.2.2.2 HSI task support verification confirms that the HSI provides all alarms, information, control and procedures required for personnel tasks.

**FOLLOW-UP RAI:**

The response does not provide sufficient detail to give the staff reasonable assurance that the HFE process will address how procedures will be verified that they are correct and can be carried out, how the final validation of procedures will be realized using an integrated system simulation, and how modified procedures will be verified with respect to content, format, integration, and effect on personnel tasks significant to plant safety.

Please provide the detailed information requested in RAI 18.0-51.

**ANSWER:**

The following will be added to Section 5.10.2.2.2 to clarify the process used to verify that the procedures are correct and can be carried out:

In the HSI task support verification, the HSIs and their characteristics (as defined in the HSI inventory and characterization) are compared to the personnel task requirements identified in the task analysis, by the HFE V&V team. In addition, Plant designers, including plant safety analysis engineers, verify draft procedures from a plant system design point of view and plant safety. Static task support verification confirms the procedures and displays have the necessary information and controls.

The following will be added to Section 5.10.2.2.4 to clarify how procedure validation will be realized using an integrated system simulation:

Integrated system validation is conducted after significant HEDs that are identified in verification reviews are resolved. Dynamic validation confirms the procedures and displays using a full scale plant simulator test facility. Validation test scenarios are designed and monitored by the HFE V&V team. HSIS problems are extracted as human engineering discrepancies (HEDs) and are tracked to closure using the HFE issues tracking system.

The following will be added to Section 5.8.2 to clarify the process for modifying procedures:

After the plant is constructed and starts operation, operating experience of other plants and the changes that are made in the plant, including changes to HSI designs of the HSI system, are to be verified for needs of procedure changes. Modified procedures are verified, by the HFE V&V team, with respect to content, format, integration, and effect on personnel tasks significant to plant safety.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-52**

**Clarify CBP system process.**

In the topical report, MHI describes a computer-based operating procedure (CBP) system for use in the US-APWR HSI design. There is no description of the process used to derive and evaluate the computer-based procedure system. Please explain the process through which the impacts of providing procedures by computer will be identified, how justifications for the use of CBPs over paper-based procedures will be documented, and how an analysis of the loss of CBPs will be performed and documented.

**MHI Response:**

The process for developing the computerized procedure system was the same as the process for all other features of the Japanese HSI System. The computerized procedures are evaluated through the HSI V&V process using a full-scale plant simulator, as explained above. The V&V encompasses use of the computer based procedure system during normal and abnormal plant conditions and all degraded HSI conditions, including loss of the electronic procedures. As stated in Section 5.8.1.b "Emergency procedures consider the degraded HSI conditions described in Section 4.11. Section 4.11.3 states "The criteria based on the operational needs are mainly defined by determining the minimum information and controls required to execute paper-based Emergency Operating Procedures (EOP)."

**Follow-up RAI:**

The response does not provide sufficient detail to give the staff reasonable assurance that the HFE process will identify the impacts of providing procedures by computer, document justifications for the use of CBPs over paper-based procedures, and analyze and document impact of the loss of CBPs.

Please provide the detailed clarifying information requested in RAI 18.0-52.

**ANSWER:**

Justification for the use of CBP is provided through compliance to the criteria of computer-based operating procedures in DI&C ISG-05 (ML072540140). To clarify this compliance, the following will be added to Section 4.8:

The design of the computer-based procedures complies with the criteria of DI&C ISG-05 (ML072540140), as follows:

**General Review Criteria:**

1. The computer-based procedure system is designed as an integral part of the Basic HSI System for the Main Control Room.
2. The CBP system ensures the procedure user (e.g., operators) is always in control of the procedure system, since bookmarks can be entered only by the user and only the user can initiate page or procedure selection. Other aspects of criteria 2 are not applicable to the Basic HSI System, because there is no control or information automation in the CBP system.
3. The configuration controls within the design and the procedure modification process ensure the computer-based procedure system always presents the most recently approved and issued version of a procedure.
4. V&V activities ensure that the computer-based procedure system always displays the selected procedure. Failure to display a procedure is easily recognized and prompts the operator to utilize backup HSI.
5. The computer-based procedure system allows the operator to easily transition from one procedure to another procedure, at any time through the use of multiple procedure VDUs and multiple procedure windows within each VDU.

**Backup Procedures Review Criteria:**

6. Back-up paper procedures are maintained for continued operation under degraded HSI conditions (i.e. loss of non-safety VDUs), and accident mitigation and/or safe shutdown under degraded HSI conditions (i.e. loss of non-safety VDUs or CCF affecting all VDUs), and emergency response . .
7. Backup paper procedures are easily accessible in the MCR. Paper procedures are used under all conditions at the RSR, TSC and EOF; these procedures are easily accessible in these locations.
8. The computer-based procedures and backup paper procedures are generated from the same original COTS computer files. All are under the same configuration controls.
9. The ability for operators to quickly, easily and effectively transition to backup procedures is confirmed through formal V&V activities, which include tests of the fully integrated HSI using dynamic high fidelity full scope simulation.
10. With the exception of bookmarks and navigational controls (e.g. hyperlinks), computer-based procedures look identical to backup paper procedures, such that the operator can use them equally effectively.
11. Computer-based procedures and backup paper procedures are generated from the same source file, to ensure the contents are the same.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-54**

**Clarify procedure access and use evaluation.**

No description is given of a plan for evaluating physical means through which procedures will be accessed and used. Please detail a plan for evaluating physical means through which procedures will be accessed and used.

**MHI Response:**

MHI plans both computer-based procedures, and backup paper based procedures for degraded HSI conditions. As described in Section 4.8, computer based procedures may be accessed from links on the Alarm VDU or Operational VDU. They may also be accessed directly through the Index window as shown in Figure 4.8-1 and Table 4.8-1. The following will be added to Section 4.8 "Backup paper procedures for the degraded HSI conditions described in Section 4.11 will be easily accessed from storage facilities in the MCR and RSR."

**Follow-up RAI:**

MHI's response should give more specific detail on how procedures will be accessed and used. For example, the process should address the storage of procedures, ease of operator access to the correct procedures, and laydown of hard-copy procedures for use in the control room, remote shutdown facility, and local control stations. The description in Section 4.8 and 4.11 does not give sufficient detail to address how procedures will be accessed and used.

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**ANSWER:**

Figure 4.3-5 Equipment Arrangement of Supervisor Console and Shift Technical Advisor Console will be annotated to show laydown areas for use of paper procedures in the main control room. Figure 4.3-3 Typical Layout of the US-APWR Main Control Room will be annotated to show storage facilities for paper procedures. Similar figures will be added to show laydown and storage facilities in the RSR. Although local control stations are within the scope of the HFE program, their design is not within the scope

of the Basic HSI System. Therefore, figures are not included in the Topical Report for local control stations. To ensure laydown and storage facilities for local controls are appropriately considered in the HFE program, Section 4.2.5 will be revised as follows:

The local HSI is designed with consideration of the information, controls and procedures needed, and the limits of the functions implemented. This includes HSI device selection, as well as layout of conventional controls and/or computer screens, and facilities for laydown and storage of paper procedures.

To ensure paper and computer based procedures are easily accessible the following will be added to Section 5.8.2 Procedures Development Process:

The procedure style guide also defines a hierarchical procedure numbering scheme so that procedures that have a related or similar purpose are grouped and/or placed at the same level in the hierarchy. The V&V team shall ensure that features, such as consistency in format and numbering, facilitate easy access to correct procedures.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-55**

**Clarify overall training approach.**

MHI mentions IAEA's Systematic Approach to Training, but it does not follow from the wording "is introduced" that this is the training program that will be adopted for US-APWR. MHI states that the training program for the HSI system will be developed in accordance with the NEI technical report "Template for an Industry Training Program Description" (NEI 06-13), but this NEI report contains very little detail on the design of a training program. There is very little detail on the approach to training that MHI will design for US-APWR. Please explain the overall training approach for US-APWR.

**MHI Response:**

The following change will be made to Section 5.9.1: "The IAEA's Systematic Approach to Training (SAT) program will be followed and the following points are clarified ..." Since the training program is developed in cooperation with the training department of the COL or existing applicant, the details of the training program will be provided in plant licensing documentation.

**Follow-up RAI:**

The response references a training program "developed in cooperation with the training department of the COL or existing applicant." The Topical Report does not specify that the training program will be developed in cooperation with the training department of the COL applicant. What is meant by the "existing applicant?"

---

**ANSWER:**

The following will be added to Section 5.9.5 Role of the HFE Design Team in the Training Development Program:

The training program is developed in cooperation with the training department of the COL applicant for the US-APWR or the licensee for operating plant modernization. The details of the training program

development plan are provided in plant licensing documentation. The roles of all organizations (e.g., MHI, plant owners, and vendors) are specifically defined in the Training Implementation Procedure for the development of training requirements, the development of training information sources, the development of training materials, and the implementation of the training program.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**APPLICATION SECTION:** 18.0

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**Follow-up RAI to RAI NO. : 18.0-58**

**Clarify roles of organizations in training program**

While MHI does state that HFE Design Team will provide input to training program's learning objectives, there is no description of what organizations will be responsible for the development and implementation of the training program. Please explain the roles of the organizations responsible for the training program development and implementation.

**MHI Response:**

The training program is developed in cooperation with the training department of the COL or existing applicant. MHI provides all plant documentation which establishes the basis for the training program. This includes Electrical and Mechanical Flow Diagrams, Functional Diagrams, Tech Manuals, Design Bases Documents, Setpoint and operating range documents, and accident analysis. The actual division of responsibility for development and presentation of the training material will be documented in the plant specific training program report.

**Follow-up RAI:**

The response adequately clarifies roles of organizations in the training program.

The items identified in the response that are cited as basis for the training program are inadequate as a basis. The basis for the training program should also include Licensing Basis, the OER, the FRA/FA, the Task Analysis, the HRA, the HSI Design, Plant Procedures, and V&V (c.f. NUREG-0711, rev. 2, 10.4.3(1) on Learning Objectives). Please clarify the basis for training program.

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**ANSWER:**

The following will be added to Section 5.9.1 Training Program:

The basis for the training program includes:

- Plant design documentation - Electrical and Mechanical Flow Diagrams, Functional Diagrams, Tech Manuals, Design Bases Documents, Setpoint and operating range documents, accident analysis and the Licensing Basis.
- HFE program documentation - the OER, the FRA/FA, the Task Analysis, the HRA, the HSI design, the plant procedures.
- HEDs resulting from any HFE program element, including V&V activities, whose resolution requires training emphasis.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-59**

**Clarify qualification criteria for training program organizations and personnel.**

While MHI provides some detail on qualification of training instructors, there is no detail on the qualification required of organizations and personnel for training program development. While MHI lists some of qualifications required for instructors, the detail provided is not very specific. It is unclear what is meant by some of the required skills and qualifications that are listed and how would these be used to ensure that an instructor had the required qualifications. For example, one of the qualifications listed is "working experience," but there is no explanation of type of work the instructor should have had experience. Also, for example, are the listed "assessment" items assessments that the instructor should be able to do or assessments that will be used to make sure the instructor is qualified? If these are assessments of the instructor qualifications, qualifications should include the acceptance criteria for the assessments. Qualifications for personnel and organizations should be verifiable criteria for experience, education (for personnel), skills, and capabilities for the development and conduct of training. Please detail the qualification criteria for the organizations and personnel involved in the development and conduct of training.

**MHI Response:**

The NEI 06-13A Template for training program describes qualification criteria for the organizations and personnel involved in the development and conduct of training. Since the training program is developed in cooperation with the training department of the COL or existing applicant, the details of the training program will be provided in plant specific documentation.

**Follow-up RAI:**

The staff reviewed the Reference COL applicant's FSAR which references the US-APWR design. The Training Program element of the COL was incorporated by reference with no departures (IBR). Information on the development of the training program was not provided in the COL applicant's application.

MHI states that the training program is developed in cooperation with the training department of the COL applicant, and that the details of the training program will be provided in plant specific documentation. Please clarify which aspects of the training program will be developed by MHI and which will be developed by the COL applicant.

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**ANSWER:**

See the response to RAI 18-55. The Training Program Plan defined in the plant licensing documentation defines the training program requirements. As stated, the division of responsibility between MHI and others to fulfill the requirements of the training program plan is defined in the plant specific Training Program Implementation Procedure. The division of responsibility is a commercial issue, which is not appropriate for plant licensing documentation.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-60**

**Clarify facilities and resources for training.**

The section on the operator training simulator fidelity (5.9.2) does not address the guidance contained in Regulatory Guide 1.149 "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations," Revision 3. ANSI/ANS 3.5 does not provide requirements on simulator fidelity only but also provides requirements for simulator functional capabilities, performance, and scope. MHI does not address many of the requirements stated in ANSI/ANS 3.5-1998.

It is unclear what is meant by the statement "Simulator's MCR and RSS console and their HSI system does not deviate from those of the reference." What does not deviate from the reference?

ANSI/ANS 3.5-1998 requires that many PWR parameters match reference unit data with 1% of the reference unit instrument loop range. MHI states that "The major PWR parameter (RCS flow, SG steam flow, SG feed flow, Charging flow, etc..) match reference unit data within 2% of the reference unit instrument loop range." While this satisfies ANSI/ANS 3.5-1998 requirements for the specific parameters listed, use of "etc." does not sufficiently qualify which parameters will be will not be within a 1 percent tolerance of the reference.

MHI states that the "Instructor is able to use training simulator's basic functions (initialization, switch, check, freeze/run, snapshot, slow time/fast time, recorder power off, emergency power off, backtrack, record/replay, annunciator control, etc..)." This list does not include all the instructor capabilities the simulator should support under ANSI/ANS 3.5-1998 requirements, including, for instance, the capabilities to replicate malfunctions and reproduce operator actions. Use of "etc." does not sufficiently qualify which instructor capabilities the training simulator will support.

Please provide detail on the facilities and resources such as plant-referenced simulator and part-task training simulators needed to satisfy training design requirements and the guidance contained in ANSI 3.5 and Regulatory Guide 1.149.

**MHI Response:**

The following will be added to Section 5.9.2: "The training simulator meets the requirements of Regulatory Guide 1.149 "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations."

The statement "Simulator's MCR and RSS console and their HSI system does not deviate from those of the reference." is simply restating the ANS 3.5 requirement that the simulator replicate the reference unit.

Section 5.9.2 will be revised as follows: "The following parameters will match the reference unit data within 1%:

- Temperature (T) average
- T-hot
- T-cold
- MWe
- Power range nuclear instrumentation readings
- Reactor coolant system pressure
- Steam generator pressure
- Pressurizer level.

The following parameters will match the reference unit data within 2%:

- Steam generator feeds flow
- Reactor coolant system flow
- Steam generator level
- Letdown flow
- Charging flow
- Steam flow
- Turbine first stage pressure."

Subsection 5.9.2 is not intended to be a specification for the training simulator fidelity. It is only intended to exemplify the fidelity that will be included. Subsection 5.9.2 will be revised as follows: Training simulator satisfies the requirements addressed in ANSI/ANS 3.5, including: .... Instructor is able to use training simulator's basic functions, such as ..." This is not intended to be a simulator specification" (see response above).

**Follow-up RAI:**

The RAI asked MHI to provide detail on the facilities and resources such as plant-referenced simulator and part-task training simulators needed to satisfy training design requirements and the guidance contained in ANSI 3.5 and Regulatory Guide 1.149. The response describes the training simulator only. Please clarify if there are other facilities and resources for training besides the training simulator referred to in the topical report. If there are other training facilities and resources, please identify and define them.

---

**ANSWER:**

The first bullet of Section 5.9.2 is to be revised as follows:

- Simulator's MCR and RSS console and their HSI system does not deviate from those of the reference. So, part-task simulators are unnecessary and not used.

The following will be added to Section 5.9.3:

“Class room training will be conducted using static presentation material, and computer based training using personal computers. To the extent practical the plant models used for computer based training will be the same models used in the plant-referenced simulator.”

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-64**

**Clarify training evaluation and modification plan.**

MHI does not describe a plan for the evaluation and modification of training. Please detail a plan for the evaluation and modification of training.

**MHI Response:**

Section 5.9.6 "Training Program Modifications" will be added, as follow: "Training program modifications include development of new or revised training material, changes in instructing techniques or changes in the frequency of training. Modifications to the training program, may result from: (1) HEDs identified during validation, as discussed in Section 5.10.2.2.5, (2) design changes, which are addressed in Section 5.11, or (3) from the evaluation of human performance, which is addressed in Section 5.12. Training program changes will be implemented using the same process as the development of the original training program."

**Follow-up RAI:**

MHI's response does not provide adequate detail. The response states: "Training program changes will be implemented using the same process as the development of the original training program." Since a level of detail on the original training that is adequate for staff review is not provided, the staff cannot evaluate the training modification plan.

Please clarify, what is the "original training plan?"

---

**ANSWER:**

Please see in the response to RAI No. 55. The original training program plan is documented in the plant licensing documentation. For the US-APWR, this is provided in Section 18.9. The details of the original training program development are documented in the plant specific Training Program Implementation Procedure. The changes that will be included in the next revision of the Topical Report, as explained in

the RAI responses above, are expected to provide a level of detail on the original training program that is adequate for staff review.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-65**

**Clarify periodic retraining plan.**

MHI does not describe a plan for periodic retraining. Please detail a plan for periodic retraining of personnel, including how the potential necessity of changes or increases in retraining will be evaluated following replacement of HSI systems in operating plants.

**MHI Response:**

See the response to 18.0-64.

**Follow-up RAI:**

The response simply refers to the response to RAI 18.0-64. Please provided detailed information describing the periodic retraining plan.

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**ANSWER:**

The following subsection will be added to Section 5.9:

**5.9.7 Retraining**

Personnel undergo periodic retraining. The periodicity of the retraining is established based on regulatory requirements (e.g., Training and Qualification of Nuclear Power Plant Personnel, NRC Regulations Title 10, Code of Federal Regulations, Part 50.120, Appendix E) and Human Performance Monitoring (see Section 5.12). Human performance deficiencies are identified as HEDs and tracked to resolution. HEDs may indicate the need for retraining based on a previous training program, or retraining based on a program with changes to address the specific deficiency encountered.

For operating plant upgrades or any HSI changes that occur after the initial training and initial HSI design deployment, the training program ensures plant personnel are retrained on all tasks that are affected by the new HSI

design. The extent of retraining is dependent on the extent to which the task is impacted. For example, it is unnecessary to retrain personnel on the function of a plant fluid system, if the new HSI does not change the operation or performance of that system.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-66**

**Clarify process for identifying HSI requirements.**

There seems to be conflicting information in the report about what analyses will be used to identify HSI requirements. Though it is stated in a section titled "Scope of HSI Design" that the OER, functional analysis and function allocation, task analysis, and staffing analysis stages of the HFE process will be used to identify HSI requirements, in a section entitled "Input Information to HSI Design Process" MHI states, "The output of the preceding process is input for the HSI design process. Input information includes functional requirement of operation, result of PRA, result of HRA, performance requirement for personnel, various regulatory requirement." It is unclear what is being referred to by the "preceding process" – i.e. what is the "preceding process"? In HFE process flow figure presented in the HRA section of the report (Figure 5.6-1), the only HFE program element feeding into the HSI design element is the Staffing & Qualification element – though it may be that this figure was not intended to provide detail on inputs into the HSI design.

Because of these conflicting statements and the lack of detail on the process through which HSI requirements will be identified, it is unclear how MHI intends to identify HSI requirements. Requirements for the HSIs should identified from the OER, the functional requirement analysis and function allocation, the task analysis, and staffing/qualifications and job analyses. In addition, risk-important human actions, as identified by the PRA/HRA, should be addressed by the HSI design. Please provide detail on how requirements for the HSIs will be identified from the OER, the functional requirement analysis and function allocation, the task analysis, staffing/qualifications and job analyses, and risk-important human actions identified from the PRA/HRA.

**MHI Response:**

Section 5.7.2 "Scope of HSI Design" will be revised as follows: "The HFE program encompasses the HSI used by operators and operations support personnel in the MCR, RSR, TSC and EOF. In addition, the program encompasses HSI in local areas of the plant which supports:

- On-line testing, radiological protection activities, and required chemical monitoring supporting technical specifications
- Maintenance required by technical specifications

**18.0-86**

- Emergency and abnormal conditions response”

The sources of input to the HSI design process currently in Section 5.7.2 will be moved to 5.7.3.1, with clarification that all previous HFE program elements provide input to the HSI design. In addition, the following will be added to Section 5.7.3.1: “Issues from all program elements that may impact the basic HSI design features, as described in Section 4, are entered into the HFE Issues Tracking System. These issues are tracked to closure through completion of the HSI design process. Other outputs of previous program elements provide input to development of the plant specific HSI inventory (i.e., alarms, indications, controls, and procedures).”

The detailed HSI design plan is a plant specific document. For example, for the US-APWR the HSI Design Program element is described in DCD Section 18.7. This plan includes generation of an HSI Design Report, which summarizes the HSI design process and design description. For the US-APWR this report is an ITAAC commitment.

**Follow-up RAI:**

Little detail is provided in the response on the process the MHI will use for identifying requirements for each of the previous analyses. Please provide greater detail on how requirements for the HSIs will be identified.

---

**ANSWER:**

The key inputs for each HFE Program Element analysis (OER, FRA/FA, HRA, TA, SA) are defined within the section of the Topical Report that describes that program element. Additional detail is provided in the plant specific HFE program plans and the plant specific HFE implementation procedures. For example, for the US-APWR the HFE program plan for each element is provided in Chapter 18 of the DCD. The Implementation Procedure for the OER program element was provided in the Phase 1a V&V report submitted December 2008. The Implementation Procedures for the FRA/FA, HRA and TA program elements are provided in the HSI Design Technical Report that will be submitted June 30, 2009. The Implementation Procedure for the SA program element will be provided in Phase 2b of the HFE program. Sections 5.7.2 and 5.7.3.1 explain the analyses that provide input to the HSI Design program element. For the US-APWR, these key input requirements are expanded in the HSI Design Program Plan provided in Section 18.7.7.2.1 of the DCD.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-67**

**Clarify analysis of personnel task requirements process.**

Analysis of personnel task requirements is described in Sections 5.7.2 and 5.7.3.1. There is nothing added in the topical report over the high-level criteria provided in NUREG-0711, Rev. 2 for MHI's plan for implementing personnel task requirements analysis. Please provide details on how identified task requirements will be used to identify HSI requirements.

**MHI Response:**

The task analysis generates the HSI inventory, including the HSI design characteristics of that inventory, necessary to support personnel task requirements. See the response to 18.0-36.

**Follow-up RAI:**

Personnel task requirements should be identified from the OER, the FRA/FA, the Task Analysis, and staffing/qualifications and job analyses. Please clarify how the task analysis generates the HSI inventory and its design characteristics, and how the HSI inventory support personnel task requirements.

---

**ANSWER:**

The following will be added to Section 5.7.3.1 Input Information to HSI Design Process

- Operational experience review – Lessons learned from other complex human-machine systems, especially predecessor designs and designs involving similar HSI technology are used as an input to HSI design.
- Functional requirement analysis and function allocation – The HSIs support the operator's role in the plant (e.g., appropriate levels of automation and manual control).
- Task analysis – The set of requirements to support the role of personnel is provided by task analysis. The task analysis identifies:

- Tasks that are necessary to control the plant in a range of operating conditions for normal through accident conditions
- Detailed information and control requirements (e.g., requirements for display range, precision, accuracy, and units of measurement)
- Task support requirements (e.g., special lighting and ventilation requirements)
- Risk-important HAs and their associated performance shaping factors, as identified through HRA, are given special attention in the HSI design process.
- Staffing/qualifications and job analyses – The results of staffing/qualifications analyses provide input for the layout of the overall control room and the allocation of controls and displays to individual consoles, panels, and workstations. This establishes the basis for the minimum and maximum number of personnel to be accommodated and requirements for coordinating activities between personnel.

#### **Impact on DCD**

There is no impact on DCD.

#### **Impact on COLA**

There is no impact on COLA.

#### **Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-68**

**Clarify how system requirements will be considered in HSI design.**

MHI states in Section 5.7.2 that constraints imposed by the overall I&C system will be considered throughout the design process, but no detail is provided on how the overall I&C system constraints will be considered throughout the design process. Please provide detail on how the constraints imposed by the overall I&C system will be considered throughout the design process.

**MHI Response:**

This section will be revised as follows: "Constraints imposed by the overall instrumentation and control (I&C) system are considered throughout the HSI design process. These constraints are understood by the HSI design team based on the interdisciplinary skills and training identified in Section 5.1.2.2." The following will be added to Section 5.1.2.2: "The Design Team and V&V Team are trained in the constraints of the overall I&C design."

**Follow-up RAI:**

There is no detail provided in the response on the process used to consider how constraints imposed on the overall I&C system will be considered. The response addresses the capability of the HSI design team, but not the process used. Please provide detailed clarifying information on the process used to consider how constraints imposed on the overall I&C system will be considered.

---

**ANSWER:**

The process for how constraints imposed by the overall I&C system are considered throughout the HFE program are explained at the program management level (Section 5.1.1.2), in the FRA (Section 5.3.1), in the TA (Section 5.4.3) and in the HSI Design (Section 5.7.3.1).

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-69**

**Clarify how regulatory requirements will be addressed in the HSI design.**

MHI states in Section 5.7.2 that applicable regulatory requirements will be identified for HSI design inputs, but no detail is provided on how applicable regulatory requirements will be identified or which regulatory requirements are relevant for HSI design inputs. Please provide detail on how applicable regulatory requirements will be identified and which regulatory requirements are relevant for HSI design inputs.

**MHI Response:**

The applicable regulatory requirements are described in Chapter 3 of the topical report. As stated in Section 5.1 “The overall goal of the HFE program management is to ensure the HSI system ... satisfies all of the required regulatory requirements.” Conformance to these requirements is assured through the interdisciplinary technical skills of the HFE Design Team and V&V Team.

**Follow-up RAI:**

There is no detail provided in the response on the process used to identify applicable regulatory requirements. Chapter 3 contains a listing of regulatory documents, codes, and standards with short descriptions of potentially relevant content. Please clarify in greater detail what design process MHI will use to identify and incorporate specific regulatory requirements.

---

**ANSWER:**

MHI used the Standard Review Plan NUREG-0800 and RG 1.206 to identify regulatory requirements and guidance pertinent to the HSI design and the HFE process. The method for compliance to these regulatory requirements and guidance is the result of MHI's HSI design and HFE process experience in Japan and MHI's knowledge of HSI designs and HFE practices in the US, and the result of executing the HFE program plan for the US-APWR.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-70**

**Clarify how other HSI design requirements will be identified.**

MHI states in Section 5.7.2 that other requirements will be identified for HSI design inputs, but no detail is provided on how other requirements will be identified or which requirements, other than those provided by other analyses in the design process, constraints imposed by the overall I&C system, and regulatory considerations, will be relevant for HSI design inputs. Please provide detail on how HSI design requirements other than those provided by other analyses in the design process, constraints imposed by the overall I&C system, and regulatory considerations will be identified.

**MHI Response:**

The following will be added to Section 5.7.2: "The concept of operations is encompassed by the functional requirements report and staffing report which are the output of Sections 5.3 and 5.5, respectively. These reports focus on changes from the reference design(s), which are determined primarily from the OER in Section 5.2. The Task Analysis from Section 5.4 is the primary input to design of the HSI inventory. That inventory is implemented within the HSI features, described in Section 4 and in accordance with the design details documented in the Style Guide. The style guide is developed based on historical practices, changes as needed per the OER, and in conformance to the guidance of NUREG-0700. HRA identifies the portion of the HSI design that requires special attention during all phases of the HFE program, including V&V. The HSI design is documented as described in Section 5.7.3.3. Testing and evaluation of the HSI design is described in the Verification and Validation phase of the HFE program, as described in Section 5.10."

**Follow-up RAI:**

There seems to be no direct treatment in MHI's response of how HSI design requirements other than those provided by other analyses in the design process, constraints imposed by the overall I&C system, and regulatory considerations will be identified. The response given is more programmatic than implementation plan level.

Please provide greater detail describing how HSI design requirements other than those provided by other analyses in the design process, constraints imposed by the overall I&C system, and regulatory considerations will be identified.

---

**ANSWER:**

Section 5.7.3.1 Input Information to HSI Design Process will be revised as follows:

- Other Requirements – Other plant specific requirements are identified from plant specific documentation and used as inputs to the HSI design. Plant specific documentation includes, for example, electrical and mechanical flow diagrams, functional diagrams, tech manuals, design bases documents, setpoint and operating range documents, accident analysis, the D3 coping analysis, etc.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-71**

**Clarify the concept of operations.**

Section 5.7.2, "Scope of HSI Design," is a restatement and précis of much of the detailed NUREG-0711, Rev. 2 review criteria for HSI design process. NUREG-0711, Rev. 2 provides detailed review criteria on a number of issues with respect to the HSI design process.

MHI provides no detail other than an overall description of computer display style guide topics. Please provide detail on the following:

- how a concept of operations will be developed and what it will describe,
- how functional requirements for the HSIs will be developed and which issues and HSI systems they will address,
- how the HSI designs will address functional requirements,
- how HSI concept designs will be developed, evaluated, and used to identify HSI design performance requirements,
- how detailed HSI designs will be specified through the use of a style guide, consideration of HSI design principals, risk-important HAs, and the many factors, conditions, analyses, tasks, etc. significant for HSI designs, as explained in the NUREG-0711, Rev. 2 review criteria
- how the style guide contents will be developed, what its overall content will be and how it will be used for HSI design,
- how design modifications will be addressed,
- how HSI designs will be tested and evaluated, including through trade-off evaluations and performance-based tests, and how the HSI designs will be documented.

**MHI Response:**

As stated in Section 5.3 "... the focus of functional requirements analysis is to identify any changes from historical practices (i.e., a detailed evaluation of unchanged practices is not ... conducted)." The following will be added to Section 5.3: "The function analysis and allocation report will document the function allocation for major plant functions, with the primary focus on functions of safety significance. Where the function allocation is different than historical practices the change is justified based on change drivers, the function allocation hierarchy described in Section 5.3.1, and the

function allocation principles described in Section 5.3.2. Function allocation changes from historical practices are emphasized in all aspects of the HFE program, including V&V.”

**Follow-up RAI:**

The response does not address concept of operations. The response focuses on the use of the functional allocation analysis, but not concept of operations. Please provide the necessary detailed information to satisfy the original 18.0-71 RAI.

Please specify which “historical practices” are being considered for FRA/FA, as referred to in the response.

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**ANSWER:**

The following will be added to Section 5.7.2:

The concept of operations is as described in Section 4.1, and includes:

- Crew composition (Section 4.1.f)
- Roles and responsibilities of individual crewmembers (Section 4.1.g)
- Personnel interaction with plant automation (Sections 4.1.a, 4.1.b, 4.1.e)
- Use of control room resources by crewmembers (Sections 4.1.c and 4.1.d)
- Methods used to ensure good coordination of crewmember activities, including non-licensed operators, technicians, and maintenance personnel. These coordination tools/methods include:
  - Large display panel (LDP) (Section 4.9)
  - LCSs (Section 4.2.5)
  - Tagging (Section 4.5)

In addition, distribution of plant data via the unit bus and the plant station bus is described in MUAP-07004. Voice communications systems and video communications systems, such as industrial television (ITV), are described in plant licensing documentation.

The following will be added to Section 5.3 Functional Requirements Analysis and Function Allocation:

“Historical practices” refers to practices in Japanese PWRs which are essentially the same as practices in operating Westinghouse PWRs in the US. The FRA/FA will identify any differences in historical practices that are pertinent to the analysis.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification  
Mitsubishi Heavy Industries  
Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2  
**SRP SECTION:** 18 – Human Factors Engineering  
**APPLICATION SECTION:** 18.0  
**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-72**

**Clarify functional requirements specification process.**

Functional requirements specification is described in Section 5.7.2. The description is a restatement of the high-level NUREG-0711, Rev. 2 criteria. Please provide detail on the process for specifying functional requirements for HSIs.

**MHI Response:**

Section 5.7.2 is intended only to explain how the functional requirements are used in development of the HSI design. The process for developing the functional requirements is described in Section 5.3.

**Follow-up RAI:**

Section 5.3 of the topical report describes functional requirements analysis (FRA) process, not the specification of functions that the HSIs must support, which is different from the FRA. The FRA identifies functions that must be performed to satisfy plant safety. If the Function Allocation process allocates a function completely to system (i.e. totally automated) resources, that function does not need to be addressed by the HSI. Functional requirements specification of the HSI is a process of identifying the functionality that various types of HSIs (e.g. instrumentation, controls, and alarms) should provide. The topical report or the response to the RAI does not provide detail on the process for identifying the functionality that various types of HSIs should provide.

Please provide detail on the process for specifying the functional requirements for HSIs.

---

**ANSWER:**

The following will be added to Section 5.7.3:

The basic functional requirements for the HSI design described in Section 4.0 are identified in Reference 24 IEC-60964 Chapter 4, "Functional Design

Specification” with additional analytical detail provided in Appendix A, “Design Guide for Control Rooms,” Section A.4. During the plant specific design process the functional requirements for the plant specific HSI inventory are added reflecting the output from the task analysis, including alarm, information and control content and characteristics for specific displays.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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**Follow-up RAI to RAI NO. : 18.0-73**

**Clarify HSI concept design process.**

Very little of the HSI concept design process is discussed in the topical report. Please provide detail on the HSI concept design process that satisfies the NUREG-0711, Rev. 2 criteria for review of an implementation plan.

**MHI Response:**

The following will be added to Section 5.7.3.2: "The specific alarms, indications, controls and procedures, which compose the HSI system, are designed based primarily on the HSI inventory requirements resulting from the Task Analysis and the HSI styled guide. The integrated components of the HSI system are verified and validated, as described in Section 5.10. Verification activities utilize static HSI simulation tools. Validation activities employ full scale dynamic simulators."

**Follow-up RAI:**

The response does not address the HSI concept design process. The RAI asked MHI to provide detail on the HSI concept design process that satisfies NUREG-0711, Rev. 2 criteria for review of an implementation plan.

Please address the NUREG-0711, Rev. 2 review criteria for an HSI concept design process implementation plan in greater detail.

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**ANSWER:**

Section 5.7.3 will be revised as follows:

The concept and design description of Mitsubishi's standard HSI system (i.e. the Basic HSI System) are described in chapter 4.0. The Basic HSI System is a direct evolution from the Japanese Standard HSI Design. It is not a new design concept. The minor differences in the US Basic HSI design have been the result of the Phase 1 V&V program conducted with US operators, as described in Appendix C. Human performance issues identified from

operating experience with the predecessor design are tracked as HEDs and are monitored and resolved as part of the plant specific HFE process. In this section, the methodology of HSI design to guide designers in the development of the HSI inventory for the plant specific HSI System is explained.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION**

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**SRP SECTION:** 18 – Human Factors Engineering

**APPLICATION SECTION:** 18.0

**DATE OF RAI ISSUE:** 5/01/2009

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**Follow-up RAI to RAI NO. : 18.0-74**

**Clarify HSI detailed design and integration process.**

Except for a description of a style guide in Section 5.7.3.2, the HSI detailed design and integration process is not discussed in the topical report. Please provide detail on the HSI detailed design and integration process that satisfies the NUREG-0711, Rev. 2 criteria for review of an implementation plan, including criterion (10), considerations for review of design modifications.

**MHI Response:**

The following will be added to Section 5.7.3.2 “The specific alarms, indications, controls and procedures, which compose the HSI system, are designed based primarily on the HSI inventory requirements resulting from the Task Analysis and the HSI styled guide. The integrated components of the HSI system are verified and validated, as described in Section 5.10. Verification activities utilize static HSI simulation tools. Validation activities employ full scale dynamic simulators.”

**Follow-up RAI:**

The response does not address the HSI detailed design and integration process. The RAI asked MHI to provide detail on the HSI detailed design and integration process that satisfies NUREG-0711, Rev. 2 criteria for review of an HSI detailed design and integration process implementation plan.

Please provide detail information on the HSI detailed design and integration process that satisfies the NUREG-0711, Rev. 2 criteria for review of an implementation plan, including criterion (10), considerations for review of design modifications.

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**ANSWER:**

The following will be added to Section 5.7.3.2:

The HSI detailed design process, which integrates the plant specific HSI Inventory using the Basic HSI design features, including the HSI style guide, ensures the following, for both new plant and plant control room upgrades:

- The HSI design supports personnel in their primary role of monitoring and controlling the plant, while minimizing the demands associated with interface management. The operational visual display units (VDUs) provide access to all information and controls, both Safety and Non safety. The LDP provides a continuous display to support situation awareness and crew interaction and coordination for all modes of operation.
- The HSI design addresses the safety parameter display system (SPDS) parameters referenced in 10 CFR 50.34(f)(2)(iv). The LDP provides continuous display for the status of all critical safety functions and the plant systems used to control those safety functions. The electronic procedure system supports execution of the functional recovery EOPs.
- The HSI design minimizes the probability of error in the performance of risk-important HAs and provides the opportunity to detect errors, if they should occur. There are a minimum of two actions required for all controls, to reduce the potential for erroneous operator actions, that may cause a transient. In addition, operational VDU displays are designed to support credited manual operator actions for event-based mitigation.
- All control functions are accessible in the main control room and no LCS controls are credited for normal operation or accident condition operator response under normal HSI conditions. The basis for the control room layout, and the organization of HSIs within consoles, panels, and workstations – the MCR is designed to support the range of crew tasks and staffing (MCR layout is discussed in Section 4.3.1); operational VDUs which are used during all normal and emergency modes of operation are centrally located.
- The control room supports a range of anticipated staffing situations. The design accommodates minimum and typical staffing, as described in Section 5.5; in addition, sufficient space is available to accommodate shift turnover transitions.
- The HSI characteristics, including lighting, ergonomics and layout design, mitigate excessive fatigue. The HSI characteristics support human performance under a full range of environmental conditions. The control of the control room environmental conditions, including emergency lighting, ventilation, and control room habitability, are discussed in plant licensing documentation.
- Inspection, maintenance, tests, and repair of HSIs can be accomplished without interfering with other control room tasks and without impacting plant control functions.
- The strategies for gathering and processing information and executing actions, are consistent with the needs identified in the task analysis.
- The relationships between plant systems are clearly and accurately depicted through the graphic displays presented on the Operational VDUs and the LDP.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION**

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**Follow-up RAI to RAI NO. : 18.0-75**

**Clarify the style guide development process.**

In the topical report, MHI describes the general types of guidelines that the style guide for displays contains. MHI states "The style guide conforms to NUREG-0700." -- it is unclear what MHI means by this statement. Does this mean that the contents of the style guide is consistent with NUREG-0700, "Human System Interface Design Review Guidelines," Revision 2, but could be a subset of the NUREG-0700 guidance? Are the style guide contents completely inclusive of NUREG-0700 guidance? Which revision of NUREG-0700 is referred to in this section of the topical report? Please provide detail on how the style guide will be developed, addressing criterion (1) in the HSI Detailed Design and Integration section of 0700, including, but not limited to, how the style guide will address HSI modifications.

**MHI Response:**

Section 3.5 references NUREG-0700. Section 3.0 states "Unless specifically noted, the latest version of the codes and standards issued as of the date of this document is the applicable one." Therefore, NUREG-0700 Revision 2 is the applicable reference. The following will be added to Section 5.7.3.2:

"The style guide encompasses the subset of NUREG-0700 guidance that is applicable to the HSI features described in Section 4." The following will be added to Section 5.11. "HSI modifications to a licensed design will utilize the HSI features described in Section 4. If there are changes to the basic HSI features described in Section 4, those changes will undergo a complete evaluation to determine what portions of the HFE program must be repeated. Effects on the HSI style guide will be included in this evaluation."

**Follow-up RAI:**

The response does not address how the style guide will be developed.

The response refers to NUREG-0700 Rev 2 as a code or standard -- it is neither a code nor standard. NUREG-0700 Rev 2 provides review guidelines used to evaluate HSI designs or design-specific HFE guidelines documents or style guides in accordance with NUREG-0800. It does not follow from the statement in Section 3.0 of the topical report that "Unless specifically noted, the latest version of the codes and

standards issued as of the date of this document is the applicable one." applies to the NUREG-0700 version

The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in addressing the information requested by the staff for RAI 18.0-75. Please provide detailed clarifying information describing **how** the style guide will be developed, addressing criterion (1) in the HSI Detailed Design and Integration section of NUREG-0700, including, but not limited to, how the style guide will address HSI modifications.

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**ANSWER:**

Section 3.0 will be modified as follows:

This section identifies the HSI System's compliance with applicable codes, standards and regulatory guidance. Unless specifically noted, the latest version of the codes, standard or regulatory guidance issued as of the date of this document is the applicable one.

The style guide, which is applicable to new plants and plant modifications, is being developed through a phased implementation program. The implementation process is summarized in Appendix C of the Topical Report as follows:

In Phase 1a – US Assessment of Japanese Basic HSI System, MHI identified any changes needed from the Japanese Basic HSI System due to US cultural or operating method differences. Phase 1a was conducted using a full scale simulation of the Japanese HSI System with known changes for language and cultural differences. Phase 1a uses a high fidelity simulation model for a conventional 4 loop PWR plant.

In Phase 1b – US-APWR Basic HSI System, MHI designed, verified and validated any changes needed from Phase 1a due to any Human Engineering Deficiencies (HEDs) identified from Phase 1a. The HSI system simulator of Phase 1a was modified, as necessary, for Phase 1b.

The style guide used for the HSI design used during Phase 1a was essentially the style guide for the Japanese Standard HSI System with changes for English translation. HEDs from Phase 1a, that affected the style guide, were tracked and resolved in Phase 1b. HEDs from Phase 1b, that affect the style guide, will be resolved during Phase 2. The final style guide will be developed during Phase 2.

Above mentioned activities are described in the Technical Report Part 2 of MUAP-08014 "Human System Interface Verification and Validation (Phase 1a) Part 2 submitted December 2008, and MUAP-09019 "HSI Design Technical Report" Part3 to be submitted in June 2009.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION**

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**Follow-up RAI to RAI NO. : 18.0-76**

**Clarify HSI test and evaluation methodologies.**

HSI tests and evaluations are described in Section 5.7.3.3. The NUREG-0711, Rev. 2 review criteria for HSI tests and evaluations are generally not addressed in the topical report. Please provide detail on the HSI test and evaluation methodologies, addressing the criteria in the HSI Tests and Evaluations section of NUREG-0700, including, but not limited to, how the HSI test and evaluation methodologies will address HSI modifications.

**MHI Response:**

HSI tests and evaluations are part of the V&V program described in Section 5.10. The V&V procedures and reports are plant specific documents which describe the test and evaluation details. The US-APWR DCD Section 18.10 exemplifies a plant specific V&V plan. That plan requires generation of V&V procedures and reports, which are plant specific documents.

**Follow-up RAI:**

HSI tests and evaluations should be carried out iteratively throughout the HSI design phase. Verification and validation is performed on a 'final', integrated design. The response does not address HSI tests and evaluation. The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in addressing the information requested by the staff for RAI 18.0-76.

Please provide the detail on the HSI test and evaluation methodologies, addressing the criteria in the HSI Tests and Evaluations section of NUREG-0711, including, but not limited to, how the HSI test and evaluation methodologies will address HSI modifications.

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**ANSWER:**

The following will be added to Section 5.7.3.3:

**18.0-109**

Appendices A and B described the tests and evaluations conducted for the Japanese Standard HSI System, which is the basis of the Basic HSI System described in Section 4.0. Appendix C describes the additional tests and evaluations conducted for the development of the US Basic HSI System (Phase 1), and the additional tests and evaluations that will be conducted for the plant specific application of that system (Phase 2), and the site specific application of that system. The V&V activities conducted during Phase 2b and Phase 3a of the HFE program are conducted on the 'final', integrated design. Phases 2 and 3 are applicable to new plants and operating plant modernization programs.

The US-APWR HFE Overall Implementation Procedure, provided in Part 1 of MUAP-09019 "HSI Design Technical Report", to be submitted in June 2009, describes the phased testing and evaluation process in more detail. Part 3 of that same report describes the results of the tests and evaluations conducted during the Phase 1 V&V program.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-77**

**Clarify HSI design documentation process.**

HSI design documentation is described in Section 5.7.3.3. The content of the topical report for HSI design documentation restates the NUREG-0711, Rev. 2 criteria. Please provide detail on the HSI design documentation process, addressing the criteria in the HSI Design Documentation section of NUREG-0700.

**MHI Response:**

The detailed HSI description including its form, function and performance characteristics are documented in the HSI design style guide. The basis for the HSI requirements and design characteristics with respect to operating experience and literature analyses, tradeoff studies, engineering evaluations and experiments, and benchmark evaluations are documented in the OER report, the HFE Design Report and the V&V Report. Records for the basis of the design changes are documented in the HFE Issue Tracking system.

**Follow-up RAI:**

The response indicates that the HSI description is documented in the HSI design style guide. A HSI design style guide provides guidelines for the design but does not document a description of specific, detailed HSI design's form, function, and performance characteristics or the outcomes of tests and evaluations in support of HSI design. An OER analysis does not include literature analyses, tradeoff studies, engineering evaluations and experiments, and benchmark evaluations unless they refer to work done or issues identified related to the past performance of predecessor designs. Similarly, the V&V does not contain operating experience and literature analyses, tradeoff studies, engineering evaluations and experiments, and benchmark evaluations unless they refer to work done or issues identified related to the V&V. Please further clarify the HSI design documentation process as an activity that is part of the HSI design process.

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**ANSWER:**

The following subsection will be added to Section 5.7.3:

#### **5.7.3.4 HSI Design Documentation**

Section 4 "Design Description" defines:

- US Basic HSI design basis
- US Basic HSI functional specification that includes specifications for data processing

The following design documents complete the US Basic HSI design specification:

- The US Basic HSI Style Guide, as described above.
- The US Basic HSI Nomenclature which defines the standard acronyms and abbreviations and equipment description guidelines used in the HSI design.
- The Component Control Design Guide that describes generic control logic and information processing logic to support operator control face plate operation, including associated indications and alarms.
- The following key design documents complete the integrated plant specific HSI design: Graphic display and panel layout drawings
- HSI database, which defines characteristics (e.g. instrument ranges, alarm prioritization) and links the VDU display icons, parameters, trends, alarms, soft controls, etc. and panel hardware devices to the database of the control and protection systems
- Logic and algorithm diagrams for HSI function processing, such as OK status monitoring, BISI and critical safety function monitoring.
- Detailed room and console configuration diagrams.

#### **Impact on DCD**

There is no impact on DCD.

#### **Impact on COLA**

There is no impact on COLA.

#### **Impact on PRA**

There is no impact on PRA.

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**Follow-up RAI to RAI NO. : 18.0-78**

**Clarify overall V&V plan.**

MHI's discussion of their Human Factors Verification and Validation plan is almost entirely a restatement and précis of much of the detailed NUREG-0711, Rev. 2 review criteria. NUREG-0711, Rev. 2 provides detailed review criteria on a number of issues with respect to the Human Factors Verification and Validation process. The NUREG-0711, Rev. 2 review criteria provides the detailed standards that will be used by NRC staff to verify that the applicant's proposed verification and validation methodologies include evaluations that determine if the final design will conform to HFE design principles and will enable personnel to successfully and safely achieve operational goals. The NUREG-0711, Rev. 2 review criteria indicate the verification and validation issues that the applicant's methodology must address, but does not explain or stipulate the methodologies the applicant will use. MHI should provide a detailed implementation plan that describes the human factors verification and validation methodologies that will be used for the US-APWR design. Please provide a plan for human factors verification and validation that describes the process and methodologies that will be used to determine if the final US-APWR design will conform to HFE design principles and will enable personnel to successfully and safely achieve operational goals.

**MHI Response:**

The V&V program is largely determined based on the extent of changes from the reference design. Therefore, the plan for human factors verification and validation is a plant specific licensing document. For example, the V&V plan for the US-APWR, which consists of two phases, is described in Section 18.10 of the DCD. Plant specific documents also include V&V procedures and reports. US-APWR Phase 1a V&V procedures are currently in use for the Phase 1a portion of the V&V program. The US-APWR Phase 1a V&V report will be issued by 12/2008. The Phase 1b V&V report will be issued 6/2009.

**Follow-up RAI:**

The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in clarifying the V&V plan.

The response indicates that the V&V program is based on changes from a reference design. A V&V program should be carried out on the final design and should not only include changes from a reference design. If a reference design is used, the V&V program should be carried out on the reference design and the V&V implementation plan and results for the reference design should be described. If the reference design is a design that has been certified by the NRC then the V&V program and results can be referenced by the applicant in addition to providing a description of the V&V program and results on the changes from the reference design.

Please provide a detailed plan for human factors verification and validation that describes the process and methodologies that will be used to determine if the final US-APWR design will conform to HFE design principles and will enable personnel to successfully and safely achieve operational goals.

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**ANSWER:**

The following will be added to Section 5.10:

The V&V program is conducted in multiple phases, as described at a high level in Appendix C, and in more detail in the each plant specific V&V Implementation Plan. For example, the V&V Implementation Plan for the US-APWR is provided in Section 18.10 of the DCD.

The V&V program activities conducted during Phase 1, which applies to the Basic HSI System, is generically applicable to all applications of the US Basic HSI System (i.e. to the US-APWR and operating plant upgrades). Phase 1 V&V will not be repeated. The V&V program activities conducted during Phases 2/3, as described in Appendix C for the US-APWR, will be uniquely repeated for all plant/site specific applications. Phases 2/3 are carried out on final plant/site specific HSI design. The HSI facilities for all phases of the V&V program include the complete HSI System. However, the specific V&V activities are focused on changes from the previous NRC approved reference design. Since the first application of the US Basic HSI System has no prior NRC approved reference, the V&V activities are more extensive than expected for subsequent applications. Subsequent applications of the US Basic HSI System will focus primarily on plant specific changes that result in changes to the HSI Inventory (i.e. displays, alarms, controls and procedures). The details of each plant specific V&V program are provided in each plant specific V&V Implementation Procedure.

The V&V activities conducted during each of the three phases of the US-APWR HFE Program are described in more detail in the HFE Overall Implementation Procedure provided in Part 1 of MUAP-09019 "HSI Design Technical Report" to be submitted in June 2009. The specific V&V Implementation Procedure and the results for Phase 1 are documented in Phase 1 V&V report MUAP-08014, which was submitted December 2008. The specific V&V Implementation Procedure and results for Phase 1b are documented in Part 3 of MUAP-09019 "HSI Design Technical Report" to be submitted in June 2009. The V&V process and methodologies, applied during Phase 1 to confirm the HSI System conforms to HFE design principles and will enable

personnel to successfully and safely achieve operational goals, will also be applied during Phases 2 and 3.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification  
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Docket No.52-021**

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**Follow-up RAI to RAI NO. : 18.0-79**

**Clarify performance measurement process.**

MHI lists some variables to be measured for Integrated System Validation but there is no explanation of the necessary detail required to address NUREG-0711, Rev. 2 review criteria. For the Performance Measurement activity of the Integrated System Validation, please explain what aspects of plant and personnel performance will be evaluated using the proposed measures, what the quality characteristics of these measures are, which of these measures will be used as "pass/fail" criteria for validation, which will be used for more thorough understanding and analysis of performance and errors, which measures will be sufficient for assessment of primary tasks, and which measures will be sufficient for assessment of secondary tasks.

**MHI Response:**

Performance measures are based primarily on the validation event scenarios, therefore these are documented in the plant specific validation procedure. For example, for the US-APWR a key performance measure will be the operator response time for time critical manual actions in response to plant Anticipated Operation Occurrences and Postulated Accidents with concurrent common cause failure of digital I&C systems.

**Follow-up RAI:**

The "plant specific validation procedure" referred to in the response is not identified and its role in the V&V program is not explained.

Based on the MHI response the "plant specific validation procedure" contains details of the performance measurement characteristics, selection, and criteria, detail. Therefore, please provide the "plant specific validation procedure" or provide the detailed information that is in the procedure to address RAI 18.0-79 for staff review.

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**ANSWER:**

Section 5.10.2.2.4e Performance measurement, describes the aspects of plant and personnel performance evaluated during Integrated System Validation. The following will be added to Section 5.10.2.2.4e:

In addition to the objective data of operator performance, as described above, performance measures include subjective operator and observer feedback collected via questionnaires and verbal debrief sessions, using:

- Post-scenario operator forms (including 5-point Likert rating questions)
- Post-scenario observer form
- Final operator feedback forms (including 5-point Likert rating questions)
- HED forms

For the V&V activities conducted during Phase 1, the specific performance measurement techniques, the specific applicability of those techniques, and the questionnaires are described in the V&V reports submitted in December 2008 (for Phase 1a) and June 2009 (for Phase 1b). For example, the performance acceptance criteria for each test scenario is documented in Appendix 8.4 of MUAP-09019 Part 3. The plant specific V&V Implementation Procedure for Phase 2/3 V&V activities, will document the use of similar measurement techniques, applicability and feedback methods.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2

**SRP SECTION:** 18 – Human Factors Engineering

**APPLICATION SECTION:** 18.0

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**Follow-up RAI to RAI NO. : 18.0-80**

**Clarify Situation Awareness and Cognitive Workload measurement methodologies.**

For Integrated System Validation measures of Situation Awareness and Cognitive Workload should reflect the current state-of-the-art. MHI states that video data and interviews of participants will be used for analysis of Situation Awareness and Cognitive Workload, but there is no explanation of how this data will be used and what specific measures will be derived from this data to assess Situation Awareness or Cognitive Workload. The reviewers are unaware of any general use of video data or interview data for Situation Awareness or Cognitive Workload measurement (with the exception of the use of eye movement video for measuring Cognitive Workload). Measures of Situation Awareness should reflect the state-of-the-art, such as those found in the following references:

- Collier, S. G. & Folleso, K. (1995). SACRI: A measure of situation awareness for nuclear power plant control rooms. Proceedings of an International Conference: Experimental Analysis and Measurement of Situation Awareness (pp. 115-122). Daytona Beach, FL.
- Endsley, M. R. & Garland, D. J. (Eds.) (2000). Situation awareness analysis and measurement. Mahwah, NJ: Lawrence Erlbaum Associates.

Measures of Cognitive Workload should reflect the state-of-the-art, as well. Recent overviews of cognitive workload measurement techniques are found in the following:

- Megaw,,E.D., (2005) The definition and measurement of mental workload. In: J.R. Wilson and E.N. Corlett, Editors, Evaluation of Human Work (third ed), London, Taylor & Francis.
- Young, M. S. & Stanton, N. A. (2005) Mental workload. In N. A. Stanton et al (Eds.), Handbook of Human Factors and Ergonomics Methods, Boca Raton, FL, CRC Press.

Please explain what state-of-the-art methodologies will be used in measuring Situation Awareness and Cognitive Workload in the Integrated System Validation.

**MHI Response:**

Video will not be used for the evaluation of situation awareness or cognitive workload. Section 5.10.2.2.4e "Situation Awareness" will be modified as follows "As described in Section 4.1d, the primary purpose of the Large Display Panel (LDP) is to provide Spatially Dedicated Continuously Visible (SDCV) information to operation personnel to enhance situation awareness. One purpose of the Safety VDUs is to provide SDCV displays for accident monitoring, as described in Section 4.6.1. The content of the SDCV information on the LDP and Safety VDUs is determined based on industry and NRC guidance for SDCV Minimum Inventory, as described in Section 4.12d. The content and display style guide of the LDP and Safety VDUs will be verified and validated. Therefore, since the purpose of SDCV HSI is to achieve adequate situation awareness, and the HSI design meets the best available industry and NRC guidance for SDCV HSI, situation awareness will not be measured." Section 5.10.2.2.4e "Cognitive Workload" will be revised as follows "Cognitive workloads evaluated based on the method described in subsection 5.4.3.2."

**Follow-up RAI:**

The information provided by MHI in the Topical Report and the response to the RAI is unacceptable in addressing the information requested by the staff for RAI 18.0-80.

MHI states in the response that the "HSI design meets the best available industry and NRC guidance for SDCV HSI." The LDP for the US-APWR has not been reviewed or certified by the NRC.

Also, the information provided with regards to the operational personnel's situation awareness is not adequate. Please provide detailed information clarifying the V&V program methodology for measuring situation awareness.

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**ANSWER:**

The present plan for the US-APWR LDP with SDCV information is described in the Section 4.9.

The detailed information clarifying the V&V program methodology for measuring situation awareness is to be developed in the Phase 2 V&V activities, which will complete in 2012. However, the preliminary test and results in the Phase 1 has been already described in the Technical Report MUAP-08014 "Human System Interface Verification and Validation (Phase 1a) Part 2 submitted December 2008, and MUAP-09019 "HSI Design Technical Report" Part3 to be submitted in June 2009.

In addition to the change identified above, the following will be added to Section 5.10.2.2.4e "Situation Awareness":

However, the Integrated System Validation Program explicitly evaluates the ability of operators to maintain situation awareness, especially with regard to the status of automated systems and critical safety functions. Test scenarios include instances where automatic safety systems, that support critical safety functions, fail or partially fail to actuate as required. The evaluation examines the ability of operators to detect the failures and to manually take control to maintain the critical

function. Performance acceptance criteria are established for each test scenario, and post scenario Likert rating questions address the following:

- Ability to maintain the 'big picture' with respect to current plant state and direction of process variables
- Ability to maintain awareness of the critical plant safety functions (e.g., based on the information provided on the LDP)
- Ability of the SRO to adequately supervise operator activities and control actions from the SRO workstation

The role of operators as supervisors of automated systems was explicitly addressed in the Phase 1B V&V program, as documented in Part 3 of MUAP-09019.

#### **Impact on DCD**

There is no impact on DCD.

#### **Impact on COLA**

There is no impact on COLA.

#### **Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No.52-021**

**RAI NO.:** 2<sup>ND</sup> ROUND RAI TOPICAL REPORT MUAP-07007-P R2

**SRP SECTION:** 18 – Human Factors Engineering

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**Follow-up RAI to RAI NO. : 18.0-81**

**Clarification of design implementation plan.**

The MHI topical report provides very little detail concerning design implementation of the HFE aspects of the plant. NUREG-0711, Rev. 2 lists general and specific criteria associated with plant modernization and final plant HFE design verification. MHI simply states that ITAAC will be used to verify the HSI system, and that the criteria are to be included in the DCD submittal, and briefly addresses impact on Human Actions. Please detail the overall plan for design implementation for new and modernized plants. The information provided should address the specific criteria listed in NUREG-0711, Rev. 2, including, but not limited to, those addressing modernization programs.

**MHI Response:**

As stated in Section 5.11 "For new plants [such as the US-APWR] the ITAAC is used to confirm that the implemented HSI System is consistent with the validated HSI System. Inspections, Tests, Analysis, and Acceptance Criteria (ITAAC) are included in the DCD submittal. The Design Implementation Plan element of the HFE Program Model also applies to operating plant modernization." To clarify this point, the following will be added to Section 5.11: "Design implementation is addressed in plant specific licensing documentation."

**Follow-up RAI:**

The response is adequate for the US-APWR design, but not for modernization of existing plants. Please provide details describing how the HSIs will be implemented in existing plants.

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**ANSWER:**

To address operating plant modernization, the following will be added to the first paragraph of Section 5.11:

The Basic HSI System is applied to operating plant modernization using the same analysis, design and V&V process as for new plants. The final integrated design is validated using a full scope simulator, as described for Phases 2 and 3 of the US-APWR program in Appendix C. The Design Implementation Program confirms through inspections and tests that the implemented HSI System is consistent with the validated HSI System. Any changes to the design that may be needed after final integrated validation, are assess for their risk significance. The risk significance considers the scope of the change as well as the potential impact on plant safety functions. Based on the risk significance, some or all of the previous elements described in the HFE Program Plan are executed for the modified design.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

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**Follow-up RAI to RAI NO. : 18.0-83**

**Clarification of human performance monitoring strategy.**

NUREG-0711, Rev. 2 describes five specific criteria for a human performance monitoring program. The MHI topical report does not specifically describe a human performance monitoring program – it simply describes the high-level criteria that the human performance monitoring program should address. Please provide detail on overall strategy for human performance monitoring. The information provided should address the specific criteria listed in NUREG-0711, Rev. 2.

**MHI Response:**

The following will be added to Section 5.12: “The human performance monitoring program is developed in cooperation with the training department of the COL or existing applicant. The human performance monitoring program will be described in plant licensing documentation.”

**Follow-up RAI:**

The response uses the phrase “existing applicant.” What is meant by “existing applicant”?

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**ANSWER:**

The words “existing applicant” will be changed to “potential applicant to apply HSI modernization”.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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6/30/2009

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**Follow-up RAI to RAI NO. : 18.0-85**

**Clarify which HFE program element implementation will be part of the DCD and which have been completed.**

Table 4.0-1 lists " identifies additional program plan activities conducted for US applications" that were not " elements in the HFE program implemented for Japanese PWRs" (p. 11). For HFE Program Management MHI states that "MHI's design process conforms to NUREG-0711 normally. Additional documentation is required." It is unclear what is meant by "normally" in this sentence. MHI states that "Approach is same as Japanese PWR" for the following HFE program elements:

- Operating Experience Review
- Functional Requirements Analysis and Function Allocation
- Task Analysis
- Human Reliability Analysis
- HSI Design
- Procedure Development
- Human Factors Verification and Validation

It is unclear if MHI is stating that the implementation approach used for Japanese PWRs is adequate for US applications. For Staffing and Qualifications MHI states that "MHI proposes operation with one SRO and one RO in the MCR for compliance with 10 CFR 50.54." No other detail is provided that addresses whether other aspects of the Staffing and Qualifications element included in an implementation plan. MHI states that "Implementation plan is added" for the following HFE program elements:

- Training Program Development
- Design Implementation
- Human Performance Monitoring

MHI will need to provide evidence that all HFE program elements comply with US regulations. Please clarify which HFE program element implementation plans will be included as part of the DCD for US-APWR and replacement of current HSI systems in operating plants. Please indicate which of the plans have been completed.

**MHI Response:**

Table 4.0-1 will be revised as follows “MHI’s design process conforms to NUREG-0711. However, additional documentation is required.”

The intent of Table 4.0-1 is to identify for which program elements the HFE program for US applications will use the same design process as was previously conducted for the Japanese HSI System, or where there are differences. Where the approach is the same, MHI considers the design process used for the Japanese HSI System to be adequate for US applications. This does not mean that the all Japanese program elements are directly applicable. All program elements are reassessed as described in the plant specific HFE program plan.

Table 4.0-1 provides only an applicability summary. The Staffing and Qualifications program element is described in Section 5.5.

As exemplified by Chapter 18 of the US-APWR DCD, plant specific licensing documentation will include program plans for all HFE program elements. The content of the plans will be focused on development of the plant specific HSI inventory and on changes from the Basic HSI System reference design, if necessary. The HFE program documentation for development of the Japanese HSI system is available for audit. However, as shown in Table 4.0-1, the Japanese program was not documented to the level of detail suggested in the guidance of NUREG0711. Phase 1 of the US-APWR HFE program compensates for this documentation deficiency by conducting additional V&V for the Basic HSI System with US HFE experts and US operators. Additional V&V will be conducted in Phase 2 for the completely integrated US-APWR HSI System.

**Follow-up RAI:**

In the response MHI proposes adding the following text to Table 4.0-1:

“MHI’s design process conforms to NUREG-0711. However, additional documentation is required.”

NUREG-0711 is guidance for NRC reviewers and MHI’s assertion that the “design process conforms to NUREG-0711” does not reflect the current findings of reviewing staff. It is also unclear what is meant by “MHI’s design process” – does this refer to the design process used for the Japanese design, the US-APWR design, or both?

MHI states in the response that the HFE program used for the Japanese design “was not documented to the level of detail suggested in the guidance of NUREG0711” and that “Phase 1 of the US-APWR HFE program compensates for this documentation deficiency by conducting additional V&V for the Basic HSI System with US HFE experts and US operators.” but there is no explanation of how the additional V&V in Phase 1 compensates for documentation deficiencies in the HFE program used for the Japanese design. Moreover, it is unclear what “compensates” means in this context – will MHI provide complete documentation of the HFE program for the US-APWR at a level of detail that will allow the NRC to review the methodologies used for the HFE program or will MHI provide documentation that addresses items not sufficiently addressed by the documentation of the HFE program used for the Japanese design?

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**ANSWER:**

The Basic HSI System, which is based on the Japanese Standard HSI System, conforms to HFE design principles and will enable personnel to successfully and safely achieve operational goals. More specifically, MHI believes the Basic HSI System achieves the following:

- Personal tasks can be accomplished within the required time and in accordance with specified performance criteria
- A high degree of operating crew awareness of plant conditions
- Operational vigilance is maintained with acceptable workload levels to minimize periods of operator underload and overload
- Operator error is minimized, and provisions for error detection and recovery are effective

Documentation is lacking from the Japanese HFE program to demonstrate that these goals have been achieved. Therefore, person-in-the-loop testing, using a full scope dynamic simulator, was conducted during the Phase 1 V&V activities to confirm that the Basic HSI System achieves these goals.

For each application of the US Basic HSI System, MHI will generate plant specific Implementation Plans, Implementation Procedures and Reports for each HFE Program Element described in Section 5. For the US-APWR all Implementation Plans are provided in Chapter 18 of the DCD. For the US-APWR technical report "Phase 1a - US Assessment of Japanese Basic HSI System, which was submitted June 2008, includes the Implementation Procedure and Report for the OER program element. For the US-APWR the HSI Report MUAP-09019, to be submitted June 2009, includes the Implementation Procedures and Reports for the Functional Requirements Analysis/Function Allocation, Task Analysis and Human Reliability Analysis program elements. Implementation Procedures and Reports for the remaining US-APWR program elements will be generated during Phase 2b. The documentation for these program elements are managed by ITAACs. All program element reports generated for the US-APWR identify how the prior HFE activities conducted for the Japanese Standard HSI are credited in the conclusions of that report. Additional detail to support those conclusions is included where appropriate.

#### **Impact on DCD**

There is no impact on DCD.

#### **Impact on COLA**

There is no impact on COLA.

#### **Impact on PRA**

There is no impact on PRA.

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**RESPONSE TO REQUEST FOR ADITTIONAL INFORMATION**

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6/30/2009

**US-APWR Design Certification**

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**Docket No.52-021**

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**Follow-up RAI to RAI NO. : 18.0-86**

**Clarify which aspects of the HFE program will be COL items.**

What aspects of MHI's HFE program will be COL items?

**MHI Response:**

The aspects of the HFE program that are outside the scope of approval for the DCD are documented in the Tier 1 ITAACs. ITAACs related to the Basic HSI System design will be completed during the DCD review process by MHI; these ITAACs will be removed. ITAACs related to the analysis that supports the development of the US-APWR HSI Inventory design (i.e., FA, HRA and TA) will also be completed during the DCD review process; these ITAACs will also be removed. The ITAACs related to the remaining HFE analysis and design program elements will be completed during the first COL application review. ITAACs related to V&V of the completely integrated HSI System will be completed prior to fuel load. MHI is responsible for completing all ITAACs. However, some of these ITAACs are based on design assumptions for the portion of the site specific design which is outside the scope of the DCD (e.g., switchyard connections, ultimate heat sink). It is the responsibility of the COL applicant to verify these assumptions or implement a design change process for any assumptions that are not applicable to the site specific application. Site specific COL applicant actions are identified within each section of Chapter 18 of the US-APWR DCD.

**Follow-up RAI:**

This RAI requires clarification of the appropriateness of submitting the "Basic HSI System design" as part of the US-APWR design certification.

MHI states in the response "The ITAACs related to the remaining HFE analysis and design program elements will be completed during the first COL application review." It is unspecified which HFE program elements MHI states are "remaining." The response should provide more clarity about which HFE program elements are "remaining" for a COL application. Also this statement seems to be inconsistent with the statement that "MHI is responsible for completing all ITAACs." Please provide additional clarifying information describing those aspects of MHI's HFE program that will be COL items and those that are not.

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**ANSWER:**

For the US-APWR, the OER, FRA/FA, HRA and TA program elements will be completed during the DCD review. However, any impact on these program elements due to site specific features are the responsibility of the COL applicant. The SA, HSI Design, V&V, Procedures, Training, Implementation and Human Performance program elements are covered by ITAACs. The COL applicant is responsible for fulfilling the licensing commitments related to all ITAACs. While MHI expects to lead most activities related to each of these program elements, the division of responsibility between MHI and the COL applicant is a commercial issue, which is outside the scope of licensing review.

**Impact on DCD**

There is no impact on DCD.

**Impact on COLA**

There is no impact on COLA.

**Impact on PRA**

There is no impact on PRA.

This concludes MHI's responses to the NRC's RAIs.