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TOKYO, JAPAN

July 24th, 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-09398

Subject: MHI's Responses to US-APWR DCD RAI No. 412 COLP-2546 Revision 1

Reference: 1) "Request for Additional Information No. 412 COLP 2546 Revision 1, SRP Section: 18 - Human Factors Engineering, Application Section: 18.7.2 Methodology," dated June 24th, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 412 COLP 2546 Revision 1."

Enclosed is the response to the RAI contained within Reference 1.

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

Sincerely,

Y. Ogata

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

Enclosure:

1. Responses to Request for Additional Information No. 412 COLP 2546 Revision 1

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

D081
NRO

Contact Information
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Docket No. 52-021
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Enclosure 1

UAP-HF-09398
Docket No. 52-021

Responses to Request for Additional Information No. 412 COLP 2546
Revision 1

July 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/24/2009

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

RAI NO.:	**NO. 412 COLP 2546 REVISION 1**
SRP SECTION:	**18 - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.7.2 METHODOLOGY**
DATE OF RAI ISSUE:	**6/24/2009**

QUESTION NO. 18-51

Acceptance Criteria:
NUREG-0711 criteria 8.4.1(1),(2),(3), and (4) identify information sources that should provide input to the HSI design process.

Evaluation:

In DCD rev 1 section 18.7.2, the applicant states that Japanese and international standards, Japanese nuclear power plant operating experience, and NRC-directed operating considerations are applied to the APWR HFE design. This section references topical report MUAP-07007 appendices A and B for additional discussion. In DCD, Section 18.7.2.1, "HSI Design Inputs," the applicant again states that the Japanese APWR HSI design is the initial design input for the US-APWR design. The remainder of this section restates the NUREG-0711 section 8.4.1 criteria.

By virtue of restating the NUREG-0711 criteria, the DCD provides a programmatic level commitment to use these inputs. However, there is no explanation of how design inputs are evaluated and applied as design requirements to the US-APWR main control room design. With no more information than a restatement of the NUREG criteria, the staff cannot evaluate whether appropriate methods are used to implement the criteria. As outlined below, the staff reviewed the topical report for additional detail associated with this criteria.

The topical report, appendix A outlines the developmental history of Japanese PWR Main Control Room by MHI and Japanese PWR Power Utilities. It provides a list of the technology advancements that were incorporated into the main control room and the verification and validation activities that were used to confirm functionality. The topical report, appendix B provides an overview of how the verification and validation activities were performed. Topical Report, section 5.7.3.1, "Input Information to HSI Design Process" lists the following design inputs:

- Input from the Analysis of Personnel Task Requirements including analyses

performed for operational experience review, functional analysis and function allocation, task analysis and staffing
- System requirements
- Applicable regulatory Requirements
- Other necessary requirements for US-APWR

Appendix A and B from the topical report identify how the MHI design evolved but do not explain directly how design inputs are evaluated and applied as design requirements to the US-APWR main control room design. The staff did not identify any relevant information to HSI Design Inputs in these appendixes. Topical Report section 5.7.3.1, which is not specifically referenced in the DCD but is relevant, contains a different list of design inputs than the DCD. Specifically, "Regulatory requirements" and "Other requirements" are added and Risk Important Human actions are omitted.

Information Request:

Based on this review the following information is requested:

(1) Please provide detailed information demonstrating how this NUREG criterion is implemented.
(2) Since the Topical report is referenced within the DCD as "the detailed description of the.... methodology used to develop (the) design," clarification is requested in the following areas:
    - Why are the two Design input lists different?
    - What methodology is being followed in referencing between the DCD and the topical report?
    - What "necessary requirements for the US-APWR" have been included in the "Other requirements" category?

NOTE: RAI 66,67,68 and 69 from the topical report identify similar concerns. The RAI response improved the Topical Report's organization of information pertaining to design inputs but did not address how design requirements are developed from design inputs.

ANSWER:

Followings are provided for each NUREG criterion;

(1) Analysis of Personnel Task Requirement

The following analyses were conducted for identifying requirements for the HSI design;

-OER

The OER was conducted. Human Engineering Discrepancies (HED) were identified for any human performance deficiencies that are not resolved by the Basic HSI System or the US-APWR HSI System. Those HEDs are tacked in the HFE Issues Tracking System. Design solutions to resolve the HEDs, and thereby improve the HSI design, are evaluated by the HFE Expert panel. The OER was documented in Part 1 of the technical report "HSI V&V (Phase 1a)" (MUAP-08014).

-FRA/FA

The FRA/FA was conducted to allocate functions and identify specific parameters, manual controls and automatic control that support critical safety functions and power production functions. These allocations, parameters and controls are used for input to the HSI display design and personnel roles in the MCR and local stations. The FRA/FA was documented in Part 2 of the Technical Report "HSI Design" (MUAP-09019).

-Task Analysis

Task analysis for risk important human actions was conducted to identified detailed information and control requirements, as well as task support requirements. The task analysis used the table top analysis and cognitive workload assessment methods.

They Task Analysis provides specific requirements for HSI display design. The Task Analysis was documented in Part 2 of the Technical Report "HSI Design" (MUAP-09019).

-Staffing/qualification and job analysis

The Human Reliability Analysis was conducted and identified operation staff numbers and skill levels for each significant human action step. The analysis also identified general HSI input such as function allocation and required parameters and controls. The Human Reliability Analysis was documented in Part 2 of the technical report "HSI Design" (MUAP-09019).

(2) System Requirements

HSI system configuration and constraints are defined by the overall I&C system, which is described in US-APWR DCD Chapter 7 and the Topical Report "Safety I&C System Description and Design Process" (MUAP-07004). Personnel Task Requirement Analysis is performed considering the HSI & I&C system configuration and constraints.

(3) Regulatory Requirements

The topical report "HSI System description and HFE process" (MUAP-07007) Section 3 identifies the applicable regulatory requirements as inputs to HSI design.

(4) Other requirements

Other personnel task requirements, which provide input to the HSI design, are defined in electrical/mechanical flow diagrams, functional diagrams, tech manuals, design bases documents, setpoint and operating range documents, accident analysis and the D3 coping analysis.

Impact on DCD

There is no impact on the DCD

Impact on COLA
There is no impact on the COLA

Impact on PRA
There is no impact on the PRA

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/24/2009

US-APWR Design Certification
Mitsubishi Heavy Industries
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RAI NO.:	**NO. 412 COLP 2546 REVISION 1**
SRP SECTION:	**18 - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.7.2 METHODOLOGY**
DATE OF RAI ISSUE:	**6/24/2009**

QUESTION NO. 18-52

Acceptance criteria:
A concept of operations should be developed indicating crew composition and the roles and responsibilities of individual crew members based on anticipated staffing levels. The concept of operations should:

- *Identify the relationship between personnel and plant automation by specifying the responsibilities of the crew for monitoring, interacting [with], and overriding automatic systems and for interacting with computerized procedures systems and other computerized operator support systems.*
- *Provide a high-level description of how personnel will work with HSI resources. Examples of the types of information that should be identified [are] the allocation of task to the main control room or local control stations, whether personnel will work at a single large workstation or individual workstations, what types of information each crew member will have access to, and what types of information should be displayed to the entire crew.*
- *Address the coordination of crew member activities, such as the interaction with auxiliary operators and coordination of maintenance and operations should be addressed.*

Evaluation:

Generally the "Concept of Operation" is well described in MUAP-07007 section 4.

Information Request:
Additional information is requested to the following 2 specific areas:

1. The HSI design includes a significant amount of automatic control. Please provide more detail on the "concept of operation" with respect to overriding

automatic systems. (NUREG-0711 8.4.2(1) first bullet)

2. Please provide more description of the video communication systems. DCD section 18.7.2.2 mentions them and references MUAP-07007 section 4.3.1 for a description. The only description in this section is contained in Table 4.3-1 which mentions a ITV console in the MCR for monitoring, "local area, spent-fuel pit, etc." (NUREG-0711 8.4.2(1) second bullet)

Note: MUAP-07007 RAI 18-71 is titled "Concept of Operation" but addresses NUREG-0711 criteria 8.4.3 and 8.4.4.

ANSWER:

1. Section 4.1.h will be added to Topical Report "HSI System Description and HFE Process" (MUAP-07007)as follows:

   "h. Overriding automatic systems

   In general, automatic safety actuation signals are prioritized over opposite manual actuation signals. However, to allow periodic testing or maintenance, safety actuation signals can be manually inhibited by the "Pull Lock" button. (See 4.5.3 a)

   To avoid potential human error of unintentionally leaving a component in the "Pull Lock" mode after testing or maintenance, bypass alarms for each train are continuously displayed on the LDP."

2. The ITV is an optional communication tool ; DCD 9.5.2 does not describe it as a standard design. Therefore, DCD 18.7.2.2 will be changed as follows:

   "In addition, distribution of plant data via the unit bus and the plant station bus is described in Section 7.9. Communication systems for the US-APWR are described in Subsection 9.5.2."

Impact on DCD

In DCD 18.7.2.2, following sentence will be revised as Attachment 1, Page 18.7-2;

"

- Personnel interaction with plant automation (see Reference 18.7-1, Subsections 4.1.a, 4.1.b, 4.1.e, 4.1.h) "

In DCD 18.7.2.2, following sentence will be revised as Attachment 1, Page 18.7-3;

"In addition, distribution of plant data via the unit bus and the plant station bus is described in Section 7.9. Communication systems for the US-APWR are described in Subsection 9.5.2."

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-53

Acceptance Criteria:

Functional requirements for the HSIs should be developed to address:

- *the concept of operations*
- *personnel functions and tasks that support their role in the plant as derived from function, task, and staffing/qualifications analyses*
- *personnel requirements for a safe, comfortable working environment Requirements should be established for various types of HSIs, e.g., alarms, displays, and controls.*

Requirements should be established for various types of HSIs, e.g., alarms, displays, and controls.

Evaluation:

DCD section 18.7.2.3 states,

"Reference 18.7-3 identifies the key principles of functional requirements specification in Chapter 4, "Functional Design Specification," with additional analytical detail provided in Appendix A, "Design Guide for Control Rooms," Section A.4. These basic functional requirements for all HSI resources are reflected in the HSI design described in the Topical Report (Reference 18.7-1). During the detailed design process additional functional requirements for HSIs are added reflecting the output from the task analysis, including alarm, information and control content for specific displays."

Reference 18.7-3 is Design for Control Rooms of Nuclear Power Plants, IEC 964, International Electrochemical Commission, 1989.

It is not clear how IEC 964 is being used. Does the guidance in chapter 4 and Appendix A of IEC 964 supplement NUREG-0711? Is MHI implementing all of the guidance in these sections or just selected parts? The text indicates the basic requirements from this source are reflected in the HSI design. How is this accomplished?

MUAP-07007 section 5 is intended to describe the HFE Design Process but section 5.7.3.1 just summarizes the NUREG-0711 criterion. There is no description of how IEC 964 guidance is included in the HSI design process and there is no explanation of how functional requirement specifications are actually developed. With no more information that a restatement of the NUREG criteria, the staff cannot evaluate whether the methods used to implement the criterion are appropriate.

Information Request:

1. Please provide detailed information demonstrating how these NUREG criteria are implemented. This should include how functional requirement specifications are developed and how they interface with the HSI design process.
2. Please clarify how IEC 964 is used to develop functional requirement specifications.

Note: MUAP-07007 RAIs 18-71 and 72 address this same subject.

ANSWER:

See response to Topical Report MUAP-07007 RAI 18.0-67, 18.0-70, 18.0-71, 18.0-72 and 18.0-74.

Impact on DCD

There is no impact on the DCD

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-54

Acceptance Criteria:

The functional requirement specification should serve as the initial source of input to the HSI design effort. If the design is a direct evolution from a predecessor, rather than a new design concept, the criteria in this section should be considered relative to operating experience of the predecessor and the design features (e.g., aspects of the process, equipment, or operations) of the new design that may be different from the predecessor. Human performance issues identified from operating experience with the predecessor design should be resolved.

Evaluation:

In DCD section 18.7.2.4, the applicant states that the US-APWR HSI design is a direct evolution of the predecessor standard Japanese PWR HSI design, as described in MUAP-7007 and shown in Appendix B, Figure B-2. As communicated previously this is insufficient information on the predecessor design. While there is no inherent concern with the actual HFE design as described in MUAP-07007, the basis for the design must be demonstrated (for example, following NUREG-0711 guidance, does the operating experience analysis, function and function allocation analyses, and task analysis support the predecessor design and is it consistent with the US-APWR style guide). The staff would need to verify the HFE processes and HFE design of the predecessor plant before the predecessor design could become the starting point for the evolutionary design. This is because the predecessor design has not been previously approved for operation in the United States. Consequently, there is no baseline for the staff's conclusion on reasonable assurance of safety.

In the same DCD section the applicant states that the development of the standard Japanese PWR from concept phase through final design is described in MUAP-07007 appendix A. This appendix is titled, "History of development of Japanese PWR Main Control Room by Mitsubishi and Japan's PWR Power Utilities." The staff did not find this

history plus the accompanying list of design objectives and V&V activities to be an adequate description of the development of "concept phase through final design" of the predecessor standard Japanese PWR HSI design for the following reasons:

1. The HSI design process used to reach a final HSI design was not described in sufficient detail.
2. The information that has been made available on the predecessor design via submittal UAP-HF-09020 has not been organized in a fashion that demonstrates the NUREG-0711 guidelines (or some equivalent standard) have been implemented.
3. The quality of the information provided (UAP-HF-09020) has not been sufficient. Atypical word usage, poor organization, and missing information have prevented the staff from reaching conclusions on how NUREG-0711 review criteria are met.

In summary, the level of detail, organization, and quality of information provided to support the staff's review of the predecessor plant has not been sufficient to support the use of the Japanese APWR HSI design as the initial source of input for functional requirement specifications into the HSI design as stated in the second bullet of DCD section 18.7.2.4.

While not referenced directly, MUAP-07007 section 5.7.3.1 restates the first sentence of the criterion indicating "functional requirement specification would serve as the *initial source* of input to the HSI concept design" but no methodology is described for how this criterion is accomplished.

Information Request:

1. Please demonstrate how the predecessor plant HFE design meets NUREG-0711 guidance (or its equivalent).

Note: HFE Design methodology issues have been addressed in previous RAIs. Topical Report RAI 18-73 addresses this same issue.

ANSWER:

See response to Topical Report MUAP-07007 RAI 18.0-73.

Impact on DCD

There is no impact on the COLA

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-55

Acceptance Criteria:

NUREG-0711 section 8.4.4 criteria (2)-(5) contain guidance on identifying HSI functional requirements, alternative concept designs and HSI performance designs. The guidance is designed to ensure state of the art HFE technologies are appropriately considered during the HSI design process.

Evaluation:

In DCD section 18.7.2.4, the applicant restates NUREG-0711 criteria 8.4.4 (2) through (5) saying they were considered during the development of the standard Japanese PWR and the HSI design. With no more information than a restatement of the NUREG criteria, the staff cannot evaluate whether appropriate methods are used to implement the criteria. While these criteria were applied to the Japanese standard PWR HSI design rather than the US-APWR more detailed information is needed because these predecessor plants have not been approved by the staff for operation in the US. Also, Japanese predecessor plants using integrated digital control systems have not yet operated and thus have not demonstrated the HFE design via operating experience. The DCD describes changes that were made to the standard Japanese PWR HSI design that are reflected in the US-APWR but does not describe how criteria 8.4.4 (2) through (5) were applied to these changes.

Information Request:

1. Please explain how criteria 8.4.4 (2) through (5) were applied to the predecessor plants.
2. Please explain how criteria 8.4.4 (2) through (5) were applied to the HSI design changes made to the US- APWR design.

Note: This subject is also addressed in Topical Report MUAP-07007 RAI 18-71 and RAI

18-72.

ANSWER:

For Information Request No.1:

As explained in Section 5.7.3 of MUAP-07004, the basic functional requirements for the Japanese HSI design were developed from IEC-60964 Chapter 4, "Functional Design Specification" with additional analytical detail provided in Appendix A, "Design Guide for Control Rooms," Section A.4. These functional requirements were supplemented by input from plant operators during the Japanese V&V program.

For Information Request No.2:

The initial design changes made for the US Basic HSI System, which is the basis of the US-APWR HSI System, were made based on an evaluation of the design's conformance to US regulatory criteria, changes to accommodate English language translation and changes to accommodate US population ergonomics. Additional changes were made based on the HEDs from US operators in the Phase 1 V&V program.

Impact on DCD

There is no impact on the COLA

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-56

Acceptance Criteria:
Design-specific HFE design guidance (style guide) should be developed. HFE Guidelines should be utilized in the design of the HSI features, layout, and environment.

Evaluation:

In DCD section 18.7.2.5, the applicant states that The HSI detailed design and integration for the US-APWR is based on the standard Japanese HSI design. The standard Japanese APWR HSI design was developed based on generic HFE design guidance (style guide). The DCD indicates this style guide is described in the Topical Report. The criteria applicable to the content of the style guide are restated in the DCD without further example or description of how they are implemented.

The Topical Report indicates a style guide will be developed and used to define the design-specific conventions (section 5.7.1), conform to NUREG-0700 (Section 5.7.2), and provide general guidance for display format, display element and display design policy (section 5.7.3.2).

This information provides a satisfactory programmatic level commitment for developing the style guide. However, it is of insufficient detail to support staff evaluation of criterion 8.4.5 (1).

Information Request:

Please make the "Style Guide" available for review so the staff can complete their evaluation of this criterion.

Note: Topical Report MUAP-07007 RAIs 18-74 and 18-75 address this subject and must be addressed in parallel with this RAI to completely address the applicable NUREG – 0711 criteria.

ANSWER:

The Basic HSI System "Style Guide" will be available for Staff Audit by the end of this year.

Impact on DCD

There is no impact on the COLA

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-57

Acceptance Criteria:
NUREG-0711 section 8.5.4 criterion 3
For risk-important HAs, the design should seek to minimize the probability that errors will occur and maximize the probability that an error will be detected if one should be made.

Evaluation:

In DCD section 18.7.2.5, MHI restates this NUREG criterion and references the Topical report for additional detail. Also the following information is provided:

> "There are two actions required, if the operator's action may cause a spurious actuation of a system that may cause a transient. In addition, operational VDU displays are designed to support credited manual operator actions for event-based mitigation."

While understandable as a concept, it is unclear how the phrases "two actions required" and "VDU displays are designed" are translated into design requirements that specifically address this criterion.

In the Topical Report section 5.6.2, the applicant states that the HFE design gives special attention to those plant scenarios, risk-important human actions, and HSIs that have been identified by the PRA/HRA as being important to plant safety and reliability. Section 5.7, HSI design, does not specifically address risk-important actions. Section 5.7.3.1 does address the use of PRA/HRA results as inputs to the HSI design process but inconsistently. The itemized design input list at the beginning of the section does not address PRA/HRA results other than by inclusion in the catch all criterion of "Other requirements." The last sentence in the section, which again lists design inputs, does include PRA/HRA actions.

There is no information describing how the design team implements this criterion.

Information Request:
Please provide the following information:

1. In the DCD, clarify the phrases "two actions required" and "VDU displays are designed." What is specifically being done to minimize the error probability and maximize error detection?
2. Provide detailed information demonstrating how this NUREG criterion is implemented.

ANSWER:

1. In DCD Chapter Subsection 18.7.2.5, description will be changed for clarification as follows;

    "• How the design minimizes the probability of error in the performance of HAs and provides the opportunity to detect errors, if they should occur:

    - two actions, which means two touch operations, are required to activate any controls. The first action enables the soft control popup window. The second action activates the desired control. Since most control windows are normally not visible, additional touch operations are normally required to navigate to the appropriate video display and the appropriate control window.

    - For the Operational VDU, the soft control popup window is selected by touching an icon that represents the component to be controlled. The icon is presented in a graphical display that depicts the component within a system mimic diagram. Thereby, promoting correct component selection.

    - The soft control pop-up face plate contains clearly labeled English descriptors, and tag numbers that uniquely distinguish safety and non-safety components, and identify safety division designations.

    - Soft control pop-up windows show component status feedback in real time, allowing operators to immediately detect control errors. Operators can take immediate corrective actions (e.g., mid-travel valve reversal), without needing to wait for components to fully respond to the previously demanded control action.

    - If an operator action erroneously disables a safety function or erroneously creates a condition that threatens a critical safety function, BISI and CSF alarms are provided on the LDP."

2. HRA report
   The Human Reliability Analysis report in Part 2 of the Technical Report "HSI Design" (MUAP-09019), which was submitted on 30th June, identifies all risk significant human actions (HAs). The report identifies the necessary HSI design (information,

controls and ergonomic design) and staffing to minimize error probability and maximize error detection for these HAs.

Impact on DCD

The DCD Chapter Subsection 18.7.2.5 will be revised as Attachment 1, Page

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-58

Acceptance criteria:
NUREG-0711 section 8.4.5 (4)
When developing functional requirements for monitoring and control capabilities that may be provided either in the control room or locally in the plant, the following factors should be considered:

- *communication, coordination, and workload*
- *feedback*
- *local environment*
- *inspection, test, and maintenance*
- *importance to safety*

Evaluation:

The staff did not find a discussion of these factors as they apply to developing functional requirements.

Information Request:

Please provide information addressing this criterion.

ANSWER:

The functional requirements for monitoring and controls were conducted considering workload, time margin, frequency, complexity and decision making. The report was submitted as "HSI design" (MUAP-09019).

The HSI design process is described in MUAP-07007 Section 5. Table 5.4-1 identifies task considerations including communication, workload, feedback and environment. Crew coordination is identified in Section 5.7.2. Inspection, test and maintenance is identified in Sections 5.4.2 and 5.7.3.2.

Impact on DCD

There is no impact on the DCD

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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QUESTION NO. 18-59

Acceptance Review:

NUREG -0711 section 8.4.5 criterion 5
The layout of HSIs within consoles, panels, and workstations should be based upon (1) analyses of operator roles (job analysis) and (2) systematic strategies for organization such as arrangement by importance, frequency of use, and sequence of use.

Evaluation:

In DCD section 18.7.2.5, the applicant states that the basis for the control room layout, and the organization of HSIs within consoles panels, and workstations is described in the Topical Report.

Topical Report, section 4.3.2, "Operator Console Layout," states that the shape, dimension and arrangement of each console meet ergonomic design standards. No additional detail on console, panel and workstation layout was provided.

Information Request:

Please provide additional information that specifically addresses this criterion.

ANSWER:

MUAP-07007 Section 5.7.3.1 includes the following:

> "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."

To address criteria 2, the following will be added to MUAP-07007 Section 5.7.3.2:The layout for panels with conventional HSI devices (eg. alarms, indicators, controls) should follow historical practices which arrange alarms at the top of the panel, indicators in the middle and controls in the lower section. This historical practice typically supports importance, frequency of use, and sequence of use.

Impact on DCD

There is no impact on the DCD

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/24/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 412 COLP 2546 REVISION 1**
SRP SECTION:	**18 - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.7.2 METHODOLOGY**
DATE OF RAI ISSUE:	**6/24/2009**

QUESTION NO. 18-60

Acceptance Criteria:
NUREG-0711 section 8.4.5

Criterion 6
Personnel and task performance should be supported during minimal, nominal, and high-level staffing.

Criteria 7
The design process should take into account the use of the HSIs over the duration of a shift where decrements in performance due to fatigue may be a concern.

Criteria 8
HSI characteristics should support human performance under the full range of environmental conditions, e.g., normal as well as credible extreme conditions. For the main control room requirements should address conditions such as loss of lighting, loss of ventilation, and main control room evacuation. For the remote shutdown facility and local control stations, requirements should address constraints imposed by the ambient environment (e.g., noise, temperature, contamination) and by protective clothing (if necessary).

Criteria 9
The HSIs should be designed to support inspection, maintenance, test, and repair of (1) plant equipment and (2) the HSIs. The HSIs should be designed so that inspection, maintenance, test, and repair of the HSIs do not interfere with other plant control activities (e.g., maintenance tags should not block the operators' views of plant indications).

Evaluation:

In DCD section 18.7.2.5, the applicant restates NUREG-0711 criteria 6 through 9 and indicates they are described in the Topical Report. The topical report does not explain the methods used by the design team to address these aspects of the HSI design.

Information Request:

Please provide information that specifically addresses these criteria.

ANSWER:

Criterion 6 and 7

The following will be added to the Topical Report MUAP-07007 Section 5.4.3 Methodology for Task Analysis:

> "Task analysis assesses minimum staffing for each operation step. A qualitative assessment will confirm the validity of the analysis for maximum staffing conditions. Time allocations for human actions shall consider the duration of a shift, where decrements in performance due to fatigue may be a concern."

The extreme environmental conditions of Criteria 8 is addressed in MUAP-07007 Table 5.4-1.

The *inspection, maintenance, test* conditions of Criteria 9 are already addressed in MUAP-07007 Sections 4.2.1, , 5.1.1.4, 5.4.2, 5.7.3.2 and Table 4.3-1.

Impact on DCD

There is no impact on the DCD

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/24/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 412 COLP 2546 REVISION 1**
SRP SECTION:	**18 - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.7.2 METHODOLOGY**
DATE OF RAI ISSUE:	**6/24/2009**

QUESTION NO. 18-61

Acceptance Criteria:
NUREG-0711 sections 8.4.6.1 and 8.4.6.2 contain specific criteria for trade-off evaluations and performance-based tests to be incorporated within the Human-System Interface Design.

Evaluation:

In DCD section 18.7.2.6, the applicant states that the control room HSI development of the Japanese APWR included trade-off evaluations and performance based tests. There is no additional information explaining how the NUREG criteria for either trade-off evaluations or performance based testing were accomplished to support the US-APWR design. Again the Japanese APWR HFE design appears to be the starting point with no explanation of how the design was developed.

A reference to the topical report indicates the performance of operating staff conducting the evaluations and tests was evaluated and described in Appendix B of Topical Report MUAP-07007. Appendix B outlines the HFE V&V Experience in Japan. V&V is a separate and distinct element from the evaluations and tests described as part of the Human-System Interface Design element. The DCD and topical report do not recognize this difference.

Information Request:

Please provide additional information that specifically addresses criteria 8.4.6.1 and 8.4.6.2 for the USAPWR HFE design.

NOTE: This subject is also addressed in Topical Report MUAP-07007 RAI 18.0-76

ANSWER:

Appendix A, B and C of MUAP-07007 describes the tests conducted for the Japanese HSI System and US Basic HSI System. See response to Topical Report MUAP-07007 RAI 18.0 -76.

Impact on DCD

There is no impact on the DCD

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/24/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 412 COLP 2546 REVISION 1**
SRP SECTION:	**18 - HUMAN FACTORS ENGINEERING**
APPLICATION SECTION:	**18.7.2 METHODOLOGY**
DATE OF RAI ISSUE:	**6/24/2009**

QUESTION NO. 18-62

Acceptance Criteria:
18.8.3.1 HSI Design Documentation:

Criterion 1
The HSI design should be documented to include:

- *the detailed HSI description including its form, function and performance characteristics*
- *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*
- *records of the basis of the design changes.*

Criterion 2
The outcomes of tests and evaluations performed in support of HSI design should be documented.

Evaluation:

In DCD section 18.7.3 and it subsections, the applicant describes a "US-APWR HSI Design Technical Report that is to be issued. It includes descriptions of the overall design concept and its rationale, the MCR, Remote Shutdown Console, TSC, and Local Control stations that are important to safety. It does not specifically include the EOF in this list although the EOF is listed in a subsequent section which states that the safety aspects for the emergency response facilities will be described. The criteria listed in the NUREG are quoted as part of the scope to be included in the document along with the outcomes of tests and evaluations performed in support of HSI design. The description of HSI design documentation addresses the NUREG criteria with the exception of the following questions.

Information Request:

1. Will the HSI Design Technical Report be submitted as part of the DCD review or added as an ITAAC report documenting completion of the HSI design?
2. DCD section 18.7.3.1, "Overview of HSI Design and Its Key Features," does not include a description of the EOF. Please explain why it was not included.

ANSWER:

The DCD Subsection 18.7.3.1 will be corrected as shown below, to refer to the HSI Topical Report. A report which documents completion of the HFE Design program element is addressed by ITAAC 7 and 7a to 7l.

> "The HSI/HFE Topical Report (Reference 18.7-1) describes the overall HSI design concept and its rationale. This description is applicable to the MCR, remote shutdown console (RSC), and TSC. Key features of the design, such as information display, "soft" controls, CBPs, alarm processing, and control room layout, are described. The HSI Topical Report (Reference 18.7-1) includes the following:"

Impact on DCD

The DCD Subsection 18.7.3.1 will be revised as Attachment1, Page 18.7-8.

Impact on COLA

There is no impact on the COLA

Impact on PRA

There is no impact on the PRA

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

- Task analysis – The set of requirements to support the role of personnel is provided by task analysis. The task analysis is described in Section 18.4. The task analysis identifies the following:

  - 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 PSFs, as identified through HRA, are given special attention in the HSI design process. The HRA integration into the HSI design process is described in Section 18.6.

- 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. The staffing/qualifications and job analyses are described in Section 18.5.

- System Requirements – Constraints imposed by the overall I&C system, such as redundancy, equipment qualification, and coping with common mode failures are significant inputs for the HSI design and are considered throughout the HSI design process

- Regulatory and Other Requirements – Applicable regulatory requirements and industry standards, including those identified in Reference 18.7-1 Section 3.0 "Applicable Codes, Standards, and Regulatory Guidance," are inputs to the HSI design process.

18.7.2.2 Concept of Operations

The concept of operations for the US-APWR is as described in Reference 18.7-1, Section 4.1, and includes:

- Crew composition (see Reference18.7-1 Subsection 4.1.f)

- Roles and responsibilities of individual crewmembers (see Reference 18.7-1, Subsection 4.1.g)

- Personnel interaction with plant automation (see Reference 18.7-1, Subsections 4.1.a, 4.1.b, 4.1.e, 4.1.h)

- Use of control room resources by crewmembers (see Reference 18.7-1, 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) (see Reference 18.7-1, Section 4.9)

  - LCSs (see Reference 18.7-1, Subsection 4.2.5)

  - Tagging (see Reference 18.7-1, Section 4.5)

In addition, distribution of plant data via the unit bus and the plant station bus is described in Section 7.9, voice communications systems for the US-APWR are described in Subsection 9.5.2~~, and video communications systems, such as industrial television (ITV), for the US-APWR are described in Reference 18.7-1 Subsection 4.3.1~~.

18.7.2.3 Functional Requirements Specification

Reference 18.7-3 identifies the key principles of functional requirements specification in Chapter 4, "Functional Design Specification," with additional analytical detail provided in Appendix A, "Design Guide for Control Rooms," Section A.4. These basic functional requirements for all HSI resources are reflected in the HSI design described in the Topical Report (Reference 18.7-1). During the detailed design process additional functional requirements for HSIs are added reflecting the output from the task analysis, including alarm, information and control content for specific displays.

18.7.2.4 HSI Concept Design

The US-APWR HSI design is a direct evolution of the predecessor standard Japanese PWR HSI design, as described in Reference 18.7-1 and shown in Reference 18.7-1, Appendix B, Figure B-2. The development of the standard Japanese PWR from concept phase through final design is described in Reference 18.7-1, Appendix A. Figure 7.1-7 in Section 7.1 shows the conceptual MCR layout of the US-APWR. The final MCR layout, resulting from all phases of the HSI design process, is described in the HSI Design Technical Report (Reference 18.7-5).

- The primary changes from the standard Japanese PWR HSI design that are reflected in the US-APWR HSI design are described in Sections 18.2 and 18.3. These include:

  - Automating channel checks

  - Automatic isolation of a failed SG (the function is to be implemented inside protection and safety monitoring system (PSMS))

- The style guide provides procedures for determining where and how HFE guidance is used in the overall design process. The style guide is written so it can be readily understood by designers. The style guide supports the interpretation and comprehension of design guidance by supplementing text with graphical examples, figures, and tables.

- The guidance is maintained in a form that is readily accessible and usable by designers and that facilitates modification when the contents require updating as the design matures. Each guideline included in the guidance documentation includes a reference to the source upon which it is based (as applied in Reference 18.7-2).

The standard Japanese APWR HSI style guide is updated to address HSI modifications for the US-APWR, as described in the section above. The style guide specifically addresses consistency in design across the HSIs.

The HSI detailed design and integration described in the Topical Report (Reference 18.7-1) is applicable to the US-APWR. The Topical Report describes:

- How the 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 for all modes of operation.

- How the design addresses the safety parameter display system (SPDS) parameters referenced in 10 CFR 50.34(f)(2)(iv) (Reference 18.7-4). 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.

- How the 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 two actions required, if the operator's action may cause a spurious actuation of a system that may cause a transient. In addition, operational VDU displays are designed to support credited manual operator actions for event based mitigation.~~:

  - two actions, which means two touch operations, are required to activate any controls. The first action enables the soft control popup window. The second action activates the desired control. Since most control windows are normally not visible, additional touch operations are normally required to navigate to the appropriate video display and the appropriate control window.

  - For the Operational VDU, the soft control popup window is selected by touching an icon that represents the component to be controlled. The icon is presented in a graphical display that depicts the component within a

system mimic diagram. Thereby, promoting correct component selection.

- The soft control pop-up face plate contains clearly labeled English descriptors, and tag numbers that uniquely distinguish safety and non-safety components, and identify safety division designations.

- Soft control pop-up windows show component status feedback in real time, allowing operators to immediately detect control errors. Operators can take immediate corrective actions (e.g., mid-travel valve reversal), without needing to wait for components to fully respond to the previously demanded control action.

- If an operator action erroneously disables a safety function or erroneously creates a condition that threatens a critical safety function, BISI and CSF alarms are provided on the LDP.

- The basis for allocation of HSI functions to either the main control room or LCS. All control functions are accessible in the main control room and no LCS controls are credited for normal operation or accident condition operator response. 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 Reference 18.7-1 Subsection 4.3.1); operational VDUs which are used during all normal and emergency modes of operation are centrally located.

- How the control room supports a range of anticipated staffing situations – the design accommodates minimum and nominal staffing, as described in Section 18.5; in addition, sufficient space is available to accommodate shift turnover transitions.

- How the HSI characteristics mitigate excessive fatigue – lighting, as described in Subsection 9.5.3, and ergonomics, as described in Reference 18.7-1, Section 4.3, Layout Design.

- How the HSI characteristics support human performance under a full range of environmental conditions – highly controlled environment without a significant fluctuation of environmental conditions, including emergency lighting, Subsection 9.5.3; ventilation, Section 9.4; and control room habitability, as discussed in Section 6.4.

- The means by which inspection, maintenance, tests, and repair of HSIs is accomplished without interfering with other control room tasks – Reference 18.7-1, Section 4.11 "Response to HSI Equipment Failures" discusses response to HSI equipment failures without impacting plant control functions.

Overall HFE issues associated with the central alarm station (CAS) and the secondary alarm station (SAS) are discussed in Section 13.6, Security. The HSI Detailed Design and Integration process encompasses the HSI design aspects of the CAS and SAS.

18.7.2.6 HSI Tests and Evaluations

The control room HSI development of the Japanese APWR, as described in Reference 18.7-1 Appendix A, included trade-off evaluations and performance-based tests. The evaluations and testing associated with this HSI development is described in a series of historical project summary reports. This work was conducted in conjunction with Japanese nuclear utilities that provided the nuclear plant operating staff that supported the testing efforts. The performance of the operating staff was evaluated as described in Reference 18.7-1 Appendix B and the associated references. Additional tests and evaluations for the US-APWR HSI design are described in Section 18.10.

18.7.3 Results

The US-APWR HSI design results and description are documented in the HSI Design Technical Report (Reference 18.7-5).

18.7.3.1 Overview of HSI Design and Its Key Features

The HSI/HFE Topical Report (Reference 18.7-1) describes the overall HSI design concept and its rationale. This description is applicable to the MCR, remote shutdown console (RSC), and TSC. Key features of the design, such as information display, "soft" controls, CBPs, alarm processing, and control room layout, are described. The HSI Topical Report (Reference 18.7-1) includes the following:~~The US-APWR HSI Design Technical Report (Reference 18.7-5) describes the overall design concept and its rationale. This description includes the MCR, remote shutdown console (RSC), TSC, and LCSs that are important to safety. Key features of the design, such as information display, "soft" controls, CBPs, alarm processing, and control room layout, are described. The HSI Design Technical Report (Reference 18.7-5) includes the following:~~

- The detailed HSI description, including its form, function and performance characteristics
- 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
- The basis of any design changes from the Japanese APWR HSI design
- The outcomes of tests and evaluations performed in support of HSI design

18.7.3.2 Safety Aspects of the HSI

The US-APWR HSI Design Technical Report (Reference 18-7-5) also describes the US-APWR specific implementation of the following safety aspects of the HSI, which are coordinated with the I&C design:

- Safety function monitoring